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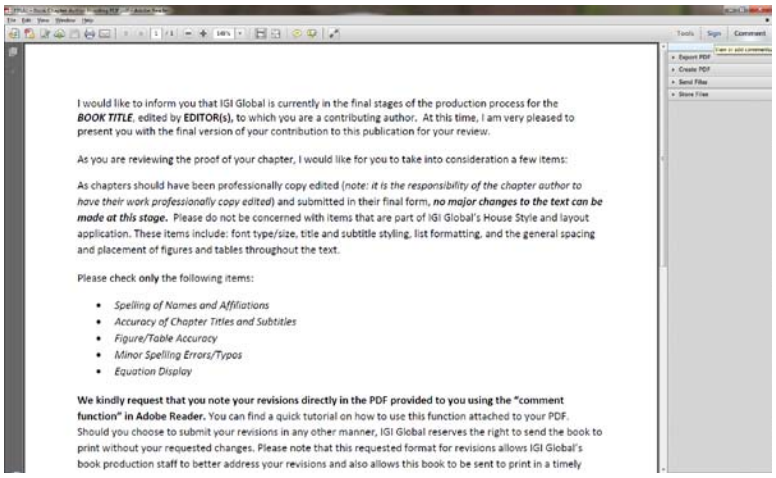

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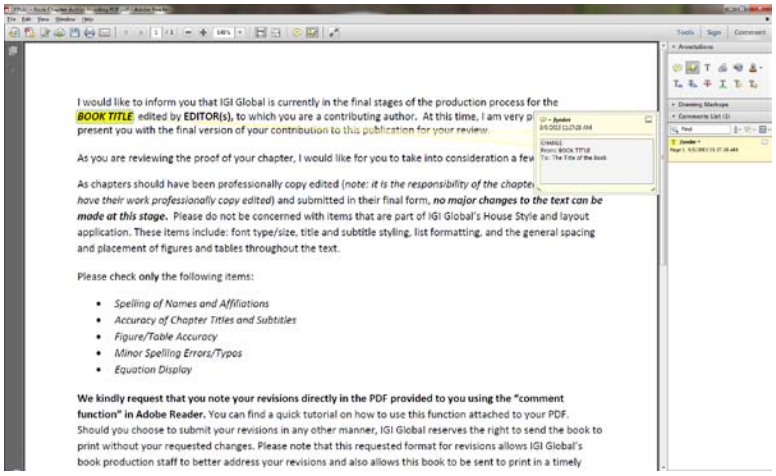

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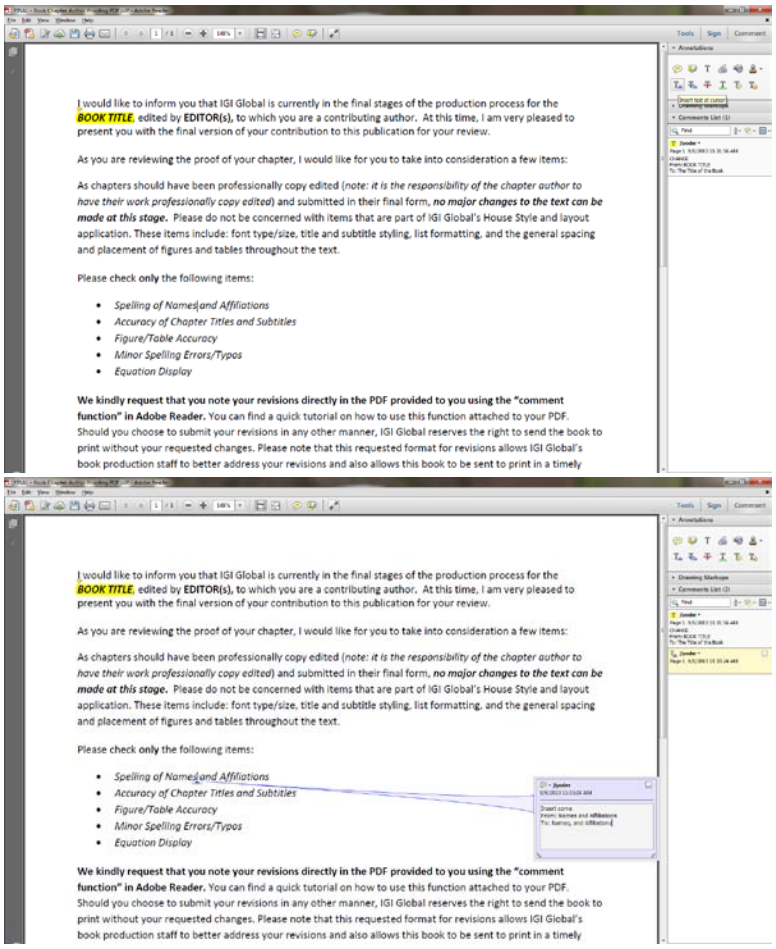

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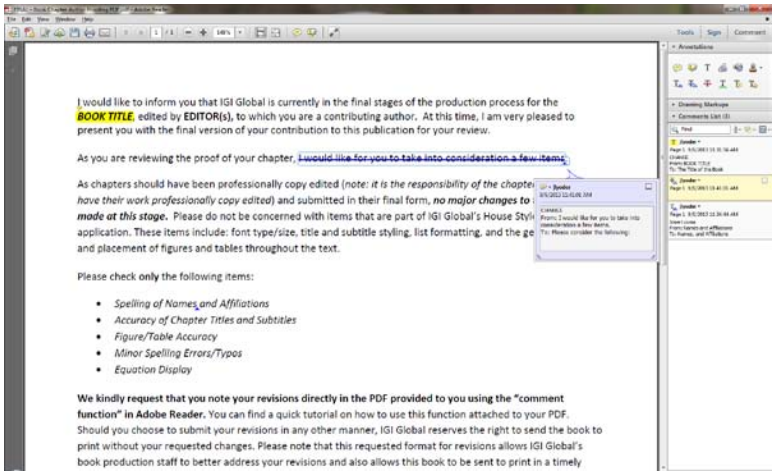

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Contemporary Ethical Issues in Engineering

Satya Sundar Sethy
Indian Institute of Technology Madras, India

A volume in the Advances in Civil and Industrial Engineering (ACIE) Book Series

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Section 1
Philosophy

Chapter 1
Engineers, Emotions, and Ethics 1
Michael Davis, Illinois Institute of Technology, USA

This chapter tries to answer the question: What part, if any, should emotion have in making engineering decisions? The chapter is, in effect, a critical examination of the view, common even among engineers, that a good engineer is not only accurate, laconic, orderly, and practical but also free of emotion. The chapter has four parts. The first, the philosophical, provides a critical analysis of the term "emotion." The second and third parts show how that analysis helps us understand the relation between emotion and engineering. It explicates what a reasonable emotion is. In short, these two sections are organized around an ethical problem concerning management's rejection of engineering judgment. The fourth part, the pedagogical, delineates how we should develop a curriculum for a course in engineering ethics. It suggests teachers of engineering ethics courses should take time in class to help students accept the fact that engineering has an emotional side, for example, that doing good engineering is likely to delight them and doing bad engineering to depress them. Lastly, it discusses the significance of emotions in the engineering decision-making process.

Chapter 2
Engineering as Normative Practice: Ethical Reflections on Tasks and Responsibilities 12
Marc J. de Vries, Delft University of Technology, The Netherlands

The concept of social practice was introduced by Alisdair Macintyre as a means for ethical reflections for professional situations. This concept has been extended by Hoogland and Jochemsen to include different types of norms. The term "normative practice" indicates that practices are determined by the norms by which they are defined. Engineering is such a normative practice, one that is part of a more complex

situation of technological developments, in which other normative practices are also involved (e.g., a government practice, a business practice, a consumer practice). The norms in a normative practice are not only ethical norms but also include task descriptions. In this chapter, the role of both non-ethical and ethical norms in engineering as normative practices is analyzed. This is illustrated by two case studies: one from military ethics (with a specific focus on the role of technology) and one from synthetic biology.

Chapter 3

Engineering Ethics in Technological Design 23
Giridhar Akula, Jawaharlal Nehru Technological University, India

Engineering's main goal is to do and invent. Today's engineering, as the motive force of technology, has reached pressing new ethical issues. The objective of this chapter is to explain the role of engineering ethics in technological design. This chapter concentrates on ethical issues that have a direct influence on the design of a product and the way it is used. In general, it focuses on ethical issues concerning safety and sustainability.

Chapter 4

Engineering Ethics Global Climate Change, and the Precautionary Principle 39
Robin Attfield, Cardiff University, UK

Besides respecting relevant codes of professional ethics, engineers should heed the principles of common morality and international law, including the Precautionary Principle, which requires action to prevent serious or irreversible harm in advance of scientific consensus, when reasons exist to credit such harm. In this chapter, this principle is shown to be applicable to many kinds of technology. An objection that seeks to assimilate it to policies of Maximin is shown to miscarry. The principle is further interpreted as concerning avoidable reductions of future quality of life. The phenomenon of anthropogenic climate change is then shown to involve challenges for engineers. In addition to principles of justice and of benevolence, the Precautionary Principle is found to be relevant once again to such decision making. Finally, considerations of humanity's limited carbon budget are adduced to indicate, in the light of these principles, the inappropriateness of extreme forms of energy extraction.

Chapter 5

Ethics is not Enough: From Professionalism to the Political Philosophy of Engineering 50
Carl Mitcham, Colorado School of Mines, USA

This chapter argues for understanding engineering ethics in terms of three principles—but then going beyond ethics to political theory. A simplified prefatory comparison between engineering and science points to the importance of ethics in engineering. Section 1 provides a historico-philosophical overview of engineering ethics in the United States, on the premise that American experience can be generally illuminating. The narrative traces a trajectory of commitments from company loyalty to public responsibility, with the public responsibility promoting public engagement. Section 2 considers three influential American cases that together suggest a duty to public disclosure. Section 3 broadens the analysis through selective reviews of engineering ethics profiles in Germany, The Netherlands, Japan, Chile, and in transnational professional engineering organizations, on the basis of which is articulated a duty not only to avoid harm but also to do good. Section 4, a critical reflection on engineering in the intensive form of research

and design, posits a synthesis of the principles of participation, disclosure, and beneficence into a duty plus respicare, to take more into account. A concluding section nevertheless suggests the inadequacy of limiting engineering ethics to ethics. Ethics in engineering like ethics generally implicates political theory. Ethics in the absence of politics demands unrealistic personal heroism; political theory without any foundation in ethics promotes tyranny.

Chapter 6
Emotional Intelligence: Its Significance and Ethical Implications in Engineering Profession..... 84
Satya Sundar Sethy, Indian Institute of Technology Madras, India

Engineers are observed as an archetype of people who carry out their professional tasks through rationality and quantitative aptitude. Thus, they do not consider themselves responsible for any sort of consequences their designed products have. But in contrast to their claim, many scholars argue that engineering products cannot be judged as value neutral as they are designed for public use. The product is good when people use it and get benefit from it and bad when tragedy occurs. The tragedy can be abated or possibly avoided if engineers would incorporate Emotional Intelligence (EI) into their professional task. EI is defined as "skills" that subsume self-awareness, self-regulation, motivation, empathy, and social skills. Thus, not incorporating EI in the engineering task brings about unwanted tragedies. Against this backdrop, this chapter critically examines the salient features of EI, three models of EI, significance of integrating EI into engineering design, methods to learn and develop EI, and ethical implications of EI in engineering profession.

Chapter 7
Religious Ethics, General Ethics, and Engineering Ethics: A Reflection..... 102
P. R. Bhat, Indian Institute of Technology Bombay, India

The objective of this chapter is to examine the underpinning relation among religious ethics, general ethics, and engineering ethics. We, the human beings, belong to one religion or the other by birth and/or by practice. There is hardly any society that is non-religious, and every major religion has religion-based ethics. Every evolved religion promotes values such as honesty, truthfulness, nonviolence, helping the needy, etc. These values are developed by major religions, such as Hinduism, Christianity, Islam, Buddhism, Jainism, etc. All these values together constitute our understanding about general ethics. Fortunately, many religions prescribe similar values, and these values are considered as general ethics, which the chapter delineates in detail. The chapter also elucidates why we have not considered agnostics' and atheists' views on religious ethics even if general ethical principles are based on religious ethics. Further, what is the need to have professional ethics such as engineering ethics when we already have religious and general ethics? The chapter argues "engineering ethics" as a professional ethics would be an autonomous system and would be independent of religious ethics and general ethics. The reason for this claim is professionals need to perform their duties in accordance with their professional codes of conduct, and not based on their religious ethics or general ethics. The chapter submits that engineering ethics is an autonomous ethics even if it has values that resemble religious or general ethics.

Section 2
Education

Chapter 8
Ethical Theories and Teaching Engineering Ethics 115
Michael S. Pritchard, Western Michigan University, USA
Elaine E. Englehardt, Utah Valley University, USA

As an area of academic study, engineering ethics focuses primarily on practical ethical issues. A primary aim of the study of practical ethics is to help students make good ethical decisions in whatever practical endeavors they may undertake, including in their chosen careers. The authors argue that reflection on the sorts of ethical problems that arise in engineering practice should be the starting point, with ethical theory coming into view primarily in this context. This is in contrast to a more "top-down" approach that tries to "apply" theory to practice only after laying out a spectrum of philosophically grounded theories, each of which attempts to give us a comprehensive picture of ethics, as such.

Chapter 9
Teaching Ethics to Engineering Students in India: Issues and Challenges 125
Reena Cheruvalath, Birla Institute of Technology and Science – Pilani, India

Most engineering colleges in India have integrated ethics courses into their curriculum for the reason that students may develop an ethical ability to engage in sound decision making. However, there are differences noticed in defining the concept of "ethics" by the engineering students and the teachers who teach them ethics. Often, it is observed that students' positions with regard to ethics courses are egoistic pragmatism while the teachers follow idealistic pragmatism. This ideological difference makes teaching ethics to engineering students a difficult task and thus undermines the effectiveness of the ethics course. The major objective of this chapter therefore is to examine the extent to which the "gap" can be merged and make the students more ethically responsible. It also helps to achieve more job satisfaction for teachers. Finally, the chapter discusses some suggestions to make engineering students more ethically sensible.

Chapter 10
Engineering Ethics Education: Issues and Student Attitudes 137
Balamuralithara Balakrishnan, Universiti Pendidikan Sultan Idris, Malaysia

In this chapter, the importance of engineering ethics education in engineering programmes is discussed, involving major elements that build ethics education. Definitions and concepts of engineering ethics are introduced, along with an engineering code of ethics. Ethical education in engineering programmes is analyzed, focusing on teaching approaches and the effect of science and technological development on engineering socio-ethical issues. Survey results are presented, which illustrate students' attitudes toward engineering ethics, where it is found that students' attitudes were poor. Some strategies are suggested to improve engineering ethical education in engineering programmes.

Chapter 11
Teaching Engineering Ethics in the Classroom: Issues and Challenges 148
Josep M. Basart, Universitat Autònoma de Barcelona, Spain

Engineering students are introduced to their profession's ethical and social responsibilities along with their education and training at university. This might be the only time and place where public welfare engagement may be promoted by the institution and acknowledged by students. Their future behavior as engineers heavily depends on the understanding and commitment they may develop during this process. The purpose of this chapter is to discuss the main points related to the teaching and learning of Engineering Ethics at universities. In order to gain insight into this complex educational scene, a set of questions are formulated and explored. The discussion of these questions amounts to explain what Engineering Education consists of, how to integrate Engineering Ethics courses into the curriculum and develop instructional designs for classroom teaching, who should assume teaching responsibilities, and finally, what Engineering Ethics goals should be. For each query, the primal issues, controversies, and alternatives are discussed.

Chapter 12
Integrating Ethics into Engineering Education 163
Chunfang Zhou, Aalborg University, Denmark
Kathrin Otrel-Cass, Aalborg University, Denmark
Tom Børsen, Aalborg University, Denmark

In this chapter, the authors aim to explore the necessity of teaching ethics as part of engineering education based on the gaps between learning "hard" knowledge and "soft" skills in the current educational system. They discuss why the nature of engineering practices makes it difficult to look beyond dealing with engineering design problems, identify the difference between knowledge and risk perceptions, and how to manage such tensions. They also explore the importance of developing moral responsibilities of engineers and the need to humanize technology and engineering, as technological products are not value neutral. With a focus on Problem-Based Learning (PBL), the authors examine why engineers need to incorporate ethical codes in their decision-making process and professional tasks. Finally, they discuss how to build creative learning environments that can support attaining the objectives of engineering education.

Chapter 13
Ethics in Design: Teaching Engineering Ethics 178
James A. Stieb, Drexel University, USA

This chapter addresses how engineers can incorporate an understanding of human beings into their technological innovations as well as some risks, responsibilities, and social values involved in technological design. It also addresses how best to teach Engineering Ethics. In short, the chapter analyzes Engineering Ethics from a philosophical and educational perspective. The objectives of this chapter are to discuss ethical theories and their significance to Engineering Ethics and relevant and significant case studies of international and national import for future technological designs. Further, the importance of including social and moral values in the engineering design process and the advantages of abiding by the professional ethics code in Mechanical Engineering are also discussed. At the end, the chapter discusses the best way to teach an Engineering Ethics course.

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Chapter 14
Widening the Industrial Competence Base: Integrating Ethics into Engineering Education 195
Pia Lappalainen, Aalto University, Finland

Amidst the macroeconomic, social, and industrial trends altering the industrial operating environment, calls have been made to shift attention from specialized but narrow technical content of engineering education to a broader competence base that better accommodates societal demands. This chapter focuses on the micro-level ethical conduct that materializes in face-to-face interaction in engineering teams. The chapter serves three aims: first, it defines the key concepts employed in the discussion. Second, it offers an account of the worth and impacts of investments in emotive skills in the engineering world. Finally, it describes a pedagogic experiment in incorporating ethics into engineering degree studies at Aalto University, Finland. The ultimate objective is to propose a teaching practice that would turn the currently marginal attempts to include ethical topics in engineers' syllabi into a mainstream mindset and philosophy that dictates decisions and drives conduct in future engineering communities.

Chapter 15
Conflict Resolution and Ethical Decision-Making for Engineering Professionals in Global Organizations 208
Charles R. Feldhaus, Indiana University-Purdue University Indianapolis, USA
Julie Little-Wiles, Indiana University Purdue University Indianapolis, USA
Brandon Sorge, Indiana University Purdue University Indianapolis, USA

As an introduction to recognizing individual and organizational conflict as well as ethical issues within global firms, the goals of this chapter are to equip Science, Technology, Engineering, and Mathematics (STEM) professionals, especially those in engineering, with solid decision-making tools, including self-awareness, ethical perspectives and theories, ethical decision-making models, and various conflict resolution approaches. Given the current challenges in business and industry that have often led to unethical practices, and ultimately conflict, it is critical that both organizational leaders and followers possess the necessary tools and perspectives to create an ethical climate that deals appropriately with various types of conflict. This chapter examines new trends in conflict coaching and the delivery of ethics training in an effort to provide the aforementioned tools and perspectives.

Chapter 16
Software Engineering Ethics Education: Incorporating Critical Pedagogy into Student Outreach Projects 233
Gada Kadoda, University of Khartoum, Sudan

The difficulties inherent in the nature of software as an intangible object pose problems for specifying its needs, predicting overall behavior or impact on users, and therefore on defining the ethical questions that are involved in software development. Whereas software engineering drew from older engineering disciplines for process and practice development, culminating in the IEEE/ACM Professional Code in 1999, the topic of Software Engineering Ethics is entwined with Computer Science, and developments in Computer and Information Ethics. Contemporary issues in engineering ethics such as globalization have raised questions for software engineers about computer crime, civil liberties, open access, digital divide,

etc. Similarly, computer-related ethics is becoming increasingly important for engineering ethics because of the dominance of computers in modern engineering practice. This is not to say that software engineers should consider everything, but the diversity of ethical issues presents a challenge to the approach of accumulating resources that many ethicists maintain can be overcome by developing critical thinking skills as part of technical training courses. This chapter explores critical pedagogies in the context of student outreach activities such as service learning projects and considers their potential in broadening software engineering ethics education. The practical emphasis in critical pedagogy can allow students to link specific software design decisions and ethical positions, which can perhaps transform both student and teacher into persons more curious about their individual contribution to the public good and more conscious of their agency to change the conditions around them. After all, they share with everyone else a basic human desire to survive and flourish.

Chapter 17
Ethical Issues for User Involvement in Technological Research Projects: Directives and Recommendations 256
Ainara Garzo, TECNALIA, Spain
Nestor Garay-Vitoria, University of the Basque Country (UPV-EHU), Spain

In recent years, it has become common for users to participate in the development of new technologies for health and quality of life. This development requires ethical issues to be taken into account. In this chapter, the researchers review the important recommendations and directives both worldwide and in European legislation in order to guide technological researchers. All research with human participants that poses any risk to them must be supervised by an external multidisciplinary entity. In addition, the participants must decide whether or not they want to participate, having been provided with all the information about the experiments and the risks of taking part. The privacy of the participants' personal data is another important issue.

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Foreword

I have been observing engineers, engineering practice, and engineering education for over 20 years now. I almost became an engineer myself. Indeed, after high school I first studied in a two-year science class where I prepared for the competitive exams required in order to enter engineering education. When I decided to change direction later on, I was already on the way to specializing at the electrochemistry engineering school of Grenoble. My first job was as a teacher in a second chance school for young people, many of them almost illiterate, despite having completed compulsory education. My following job was as a social worker with homeless people. I went back to university to study education. I then returned to the world of engineering earlier than expected. While studying alternative systems of education, an engineer who pioneered in France the inclusion of ethics in engineering education proposed that I do some research on an experimental course on engineering ethics. Two decades later I am now a social scientist and the focus of my research is mainly on engineering profession and education, ethical issues raised by engineering, and the promotion of ethical awareness among engineering students. It's clear that I was more drawn to debating with engineers, identifying the ethical issues their profession faces in our modern globalized world, discussing with students and writing papers about those questions, than to practising engineering myself.

Since discovering the academic field of engineering ethics, I have paid careful attention to the collaboration among engineers, philosophers, and other Humanities scholars in tackling the ethical issues of engineering across many countries. I have witnessed scholars' efforts to develop philosophical and ethical reflection that is linked to practitioners' experiences. I have had the good fortune of meeting a great many practising engineers and academics from a variety of backgrounds, who were eager to build bridges between their disciplines. I have met many Humanities researchers who had a real interest in engineering, not only as a theoretical issue, but also remembering that it involves human beings, and that engineering is a wonderful and critical challenge for humankind. As much as a critical approach is necessary when dealing with ethics, it is also essential to develop a better mutual understanding and for academics to remain close to the human experience of the central actors, the engineers. This is, to me, the only effective way to reach engineers and to promote, with them, the engineering profession's ethical concern.

I am very enthusiastic about Satya Sundar Sethy's efforts to contribute toward helping engineering educators find the best way to build bridges between engineering and society, develop students' ethical awareness, accompany the practitioners' effort to act more ethically, take their fair share of responsibility, and participate in the ongoing ethical discussion surrounding their professional activity. This book, which is the result of an exciting and highly practical project, is one more brick laid in constructing this new field of interest at the crossroads of Humanities and engineering, engineering ethics.

ENGINEERING ETHICS: A BURGEONING ACADEMIC DISCIPLINE

Bioethics and business ethics have long had their international conferences, their academic networks, their international scientific journals, as well as their schools of thought and their internal theoretical controversies. On the contrary, engineering ethics as an academic discipline is less well known and attracts occasional scepticism from academics as well as from practising engineers. In the USA, where there have already been many national conferences on this topic since the 1980s, academic discussions have developed after several decades of debate within the profession. When scholars from the USA began studying the ethical issues of engineering, several codes of ethics had already been published and even revised in the country. Although the first code of engineering ethics came from the UK, the genre had found highly fertile ground in the USA since the beginning of the twentieth century, and many codes from various engineers' associations have long co-existed. The attempt to reach an agreement over a common text never really succeeded, but most professional associations came to an agreement in the middle of the 1970s on the code put forward by the Engineers' Council for Professional Development (today the Accreditation Board for Engineering and Technology, ABET).

Since the publication of the first codes of engineering ethics (by the American Association of Consulting Engineers, ASCE), the USA has had a long history of discussion by engineers on ethics. Engineering ethics as a field of teaching and research also has a long history in the USA, longer than anywhere else. Since the 1970s, the USA's National Science Foundation had started to promote collaborative research between engineers and philosophers in order to better analyze the issues of engineering ethics and develop appropriate teaching materials. These collaborations resulted in conferences, published manuals and articles, many codes of ethics put on line, as well as case studies for pedagogical use. Since the mid-1980s, the ABET has increasingly required engineering programs to include the teaching of professional ethics. This culminated in the formulation of the Engineering Criteria 2000 released in 1997 and which makes it a requirement to include teachings about the ethical responsibilities of engineers.

ENGINEERING: AN INTERNATIONAL PROFESSION

The work environment of engineers covers the entire globe. Companies and engineering products cross borders easily, and move over vast regions of the world; international business and engineering have increased manifold. All over the planet, the majority of engineers work in large multinational companies. To increase their skills in working effectively with people from around the world and in order to gain an international engineering perspective, students most often study in an international context. They learn foreign languages, spend semesters abroad, and gain experience in collaborative projects with foreign students in their own country. To embrace this reality, efforts have been made within various regions of the world—in America, Asia, Europe, and beyond—to harmonize technical and engineering education. Accreditation and professional guidelines have been set up to further the mutual recognition of diplomas and titles.

ENGINEERING: A GLOBALLY TRANSFORMATIVE POTENTIAL

Risk and pollution, like engineers and engineering products, cross borders easily. Sometimes, the impacts of engineering on the environment are sudden and dramatic but more often they are indirect and subtle and may escape immediate notice and the reach of these impacts has increased over time. The side effects of engineering on society, the environment and safety of human beings and the ecosystem can be felt on a local scale as well as on the global one. The consequences of engineering decisions can be felt long after they were made and far from where they were discussed. In order to meet such challenges, especially when engaged in global projects involving multinational jurisdictions, engineers need to equip themselves with a strong awareness of both moral responsibilities and the possible implications for the decisions made in the course of their professional duties. In this context, it may not be surprising that efforts have been made to consider the possibilities of producing international codes of ethics for engineers. Indeed, since the end of the twentieth century, scholars from the USA have been calling for an international agreement on ethical standards for engineers, so far to not avail. Instead the World Federation of Engineering Organisations—an NGO in close relation with UNESCO—has designed a guideline to assist member organizations in guiding ethical behavior by formulating their own code.

A VARIETY OF ENGINEERS' RESPONSES TO THE ETHICAL QUESTIONS

The comparative analysis I have made since my doctoral research was published has shown that the way engineers and engineering associations tackle the ethical issues of their profession varies a great deal from one country to another. This doesn't mean that engineers do not have to respond to the same kind of issues, but that:

- Being an engineer (or a graduate engineer, a professional engineer, or a civil engineer) doesn't mean the same thing depending on the national, regional, and/or cultural context. There are different definitions for an engineer and also different ways of segmenting the larger definition, each of them entailing various types of social expectation;
- The feeling of belonging to a profession or a distinct group, whether social, professional, or occupational, holding specific responsibility varies from one place to another and is linked to the history of the group, how it started, as well as the challenges it may have to face;
- The type of answers given by human communities to ethical questions also varies from one place to another: some rely on codes of conduct or ethics or standards, others on the law; some rely on individual answers, others in collective ones.

For instance, codes of ethics have existed in the USA and Canada since the beginning of the twentieth century, and in Norway since 1970; In Sweden a code of honor has existed since 1929 and in Finland since 1966; in a few other countries like Australia and New Zealand, codes of ethics have been published in the 1980s and in others like Japan only in recent years; in the province of Quebec the code of ethics published by the Order of the engineers has the force of law; in yet other countries—even highly industrialized ones like Germany—there is no code of ethics for engineers. Actually, like any other outcome of engineering activity, whether technological products for the marketplace, or technical codes, or ethical codes—where these exist—the responses given to the ethical questions embody a variety of interests,

tensions, and assumptions. They reflect a common morality, but they also reflect specific circumstances of the time and place where they were designed.

- In the USA, the early interest of professional associations in codes is linked to the professionalization movement of the beginning at the twentieth century and can be understood as a means for engineers of obtaining the social recognition due to what is designated there as a profession, in opposition to the other types of occupations.
- In Germany, there is—strictly speaking—no code of ethics for engineers; however there is a document called "fundamentals of engineering ethics," which differs in genre from the codes published in the USA. In Germany, debates about ethics rose out of the ashes of the Second World War and the collaboration of engineers in some of the third Reich atrocities. In a mission statement published in 1950 they included an explicit commitment to humanity as a whole, which can be understood as a self-criticism by German engineers, who previously had understood themselves as advancing civilization by serving Germany.
- In Japan, engineering ethics was developed in the late 1990s as a result of nuclear accidents and out of the need to meet the requirements of foreign accreditation bodies like the USA's ABET. At the same period, most Japanese engineering societies published codes of ethics to respond to the challenge of deep cultural transformation involving a weakening of loyalty to tradition and an increase in individual self-interest.

The reasons for the engineering profession to have—or not to have—a code of ethics depend on many factors. The relationship between ethical debate within the profession and discussion around the promotion of ethics within engineering education also varies from country to country: this relationship is tangible in the USA and in Japan, but is not in Germany or in France. Beyond the existence of a code of ethics, which is only the tip of the iceberg, the question "what do engineering ethics and engineers' social responsibility mean for engineers?" receives various answers, which are historically and socially determined. One of the reasons for this is that these questions are linked to others—cultural and local factors–that cannot be ignored, such as:

- What does it mean in my country to be called an engineer and/or a professional engineer and /or a civil engineer? What does this calling say about what I know or am supposed to know and what others do not? What does it imply in terms of social expectation?
- Are some specific occupational activities in my country regulated by a professional order? Is it the case for engineers? Are engineers to be found in specific type of organizations?
- How do people relate to ethics and values in my culture, in my social or professional group? Do people in my country look for answers in religion, in wisdom, or being helped by personal coaches? Do they rely more on written laws or given word? Do they expect a code of ethics or a professional order to draw a line between what should be promoted and avoided? Are codes of ethics meaningful for engineers in the country where I have been trained to become an engineer?

Most American people, and engineers among them, believe that when it comes to ethics there are rules that can be applied to any situation. This is far from the case in most Asian countries where the common belief is that there are no unique rules that can apply to every situation. The way the concept of identity and responsibility is understood in Japan, has to be understood in relation to the establishment of the

Japanese nation–state under the Meiji Restoration, where harmony is a key concept. In China, professional ethics has found its roots in the Confucian culture and the concept of social order. The concepts of Dao and harmony are also very important. In Canada, engineering students learn that any breach of the code of ethics could lead to a court trial, or expulsion from his or her professional engineering association, and not being able to work as an engineer unless moving to another country, or at least another province of the country. In France, the majority of students are simply unable to imagine that there might exist somewhere in the world such a thing as a code of ethics for engineers. In the USA, academics find it hard to believe that there are countries where engineers do not belong to something called a "profession."

While we observe an increasing harmonization of engineering education all over the world, the environmental, social, and other ethical issues at stake within engineering require answers which are both global and local. We all know the famous saying "think global, act local." Engineers are for the most part acting globally and need, of course, to think globally in order to design projects that work in the global world. At the same time, I believe that finding answers to ethical questions needs to be informed by the culture from where the answers come and the questions are asked. An engineer can become more aware of the global ethical issues of engineering. She can learn to think more globally about these issues. But, her reflection will be influenced by one or more cultural and professional frameworks: where she was brought up and her engineering education, where she actually studied to become one, and where she actually works as an engineer. Scholars of engineering ethics too often ignore these important questions and teachers may take for granted that any engineering ethics textbook will be appropriate for their students.

CONTEXTUALIZING THE TEACHING OF ENGINEERING ETHICS

To enable students to familiarize themselves with a field of studies that is not their first choice and does not relate to experimental sciences, teachers need to build their courses around their students' background because their worldview is shaped by the symbolic references common to their particular culture. Thus, although the Challenger accident (1986) may be used as an engineering ethics case study with students from all over the world, it may require different approaches that take into account the students' cultural context. Looking for answers to an ethical dilemma in the code of ethics of the USA's National Society of Professional Engineers (NSPE), or studying the concept of Dao, may not be of much relevance to a French student. In another country, it may be more relevant to consult a code of professional ethics or any other kind of formal regulation, where that exists—and has meaning for the engineering community. It may also be efficacious to discuss the issues of engineering ethics as they relate to the particular philosophical framework with which the engineers and engineering students are already familiar.

To conclude, I should like to acknowledge Satya Sundar Sethy's remarkable energy and determination in completing this book, and his skilfulness in bringing together the main themes developed by the international community, including academics from the USA with their widely differing approaches. He has also given voice to Indian researchers, who are able to give global issues a new reading and another perspective, making the international community more aware of local situations and alternative frameworks for dealing with engineering ethics—at the same time helping Indian engineers also to think locally.

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Preface

Human beings by birth are ethical beings because they have a sense of judging which action is good and which one is bad. One can claim that this is "general ethics" or human conscience. But the question arises, is it adequate for professionals to judge their professional actions as good or bad. To me, certainly not, because "general ethics" is subjective and context specific, and professionals can't afford to take decisions the way they feel to take. The reason is professionals belonging to a particular profession, let us say, engineering, business, medicine, etc., are expected to do similar things as their colleagues do, even though it is repetitive in nature.

Society attests who are to be treated professionals. It also expects professionals to behave professionally. To cater the societal demands, fulfill the expectations of a profession and cope with professionalism, professionals need to abide by the professional ethics, which is common to each and every individual member of that profession, irrespective of his/her religion, caste, culture and gender. For example, physicians need medical ethics, lawyers require legal ethics, engineers need "engineering ethics," and so on. In the context of engineering profession, no doubt, engineers deserve appreciation for their innovations and discoveries, which they carry out through their rationality and quantitative aptitude. But mere rationality and quantitative skills could hold them accountable for societal insensitiveness and engineering disasters. They cannot avoid their responsibility for engineering disasters that are the consequences of their designed products. So, it is imperative for them to learn and incorporate "engineering ethics" in their professional tasks.

"Engineering Ethics" is a branch of Professional Ethics and thereby treated as an applied ethics. It is defined as "the study of the moral values, issues, and decisions involved in engineering practice" (Schinzinger & Martin, 2000). According to Harris et al. (1996), "Engineering ethics is as much a part of what engineers in particularly know as factors of safety, testing procedures, or ways to design for reliability, durability, or economy" (p. 93). Most of the engineers across the globe argue that technological designs are value neutral because they rely on rationality, reasoning abilities and quantitative aptitude skills of engineers. But this is not acceptable to many for the reason that technological innovations are not dissociated from their consequences—either good or bad. The consequence will be treated as good when people use the technology and benefit from it, and bad when tragedies occur. Technological artefacts are designed mostly for public use. So, when engineers design new artefacts, how they should integrate professional ethics into their engineering practice is the sole concern of the book. It illustrates issues pertaining to engineers' responsibilities towards technological designs in the context of understanding risks, accountability and social values.

The book addresses how engineers can incorporate the professional ethics into their practices to make engineering a success. The key discussions included in this manuscript are (a) How should engineers embrace an understanding of responsibility and social values into their technological innovations? (b) Do engineers need to discern risks, human emotions and social demands while engaging in technological designs? and (c) How should an "Engineering Ethics" course best be taught to engineering students in academic institutions, so that they can produce humane technologies? In a nutshell, this book discusses "engineering ethics" relating to philosophical, industrial, and educational fields.

OBJECTIVES OF THE BOOK

This book embraces discussions ranging from ethical theories to significance of insertion of emotion in technological designs, adaptation of risks, responsibilities, social and moral values in technological innovations.

The objectives of the book are:

- To discuss ethical theories and their significance to engineering ethics.
- To discuss relevant and significant case studies of international and national importance for future technological designs.
- To elucidate the importance of inclusion of social and moral values in the engineering decision-making process.
- To illustrate the differences between occupation vis-à-vis profession, and the advantages of abiding by the professional ethics codes in an engineering profession.
- To identify the best method(s) to teach an "Engineering Ethics" course to engineers in training or in practice.
- To analyze the techniques, principles and guidelines to maintain the harmony between risks and responsibilities in technological innovations.

To achieve these objectives, this book offers seventeen chapters, placed under three sections. The sections are philosophy, education and practice/execution. All these sections enumerate ethical issues surrounded to engineering profession. The first section comprises seven chapters, and these chapters provide theoretical-cum-philosophical background to understand the significance of professional ethics in the engineering profession. The second section embraces six chapters that delineate issues integration of ethics course in engineering curriculum. It discusses the importance and benefits of integrating professional ethics courses into engineering education. The third section comprises four chapters illustrating issues related to the use of professional ethics in engineering profession.

In Chapter 1, Michael Davis tries to answer the question: *What part, if any, should emotion have in making engineering decisions?* The chapter is, in effect, a critical examination of the view, common even among engineers, that a good engineer is not only accurate, laconic, orderly, and practical but also free of emotion. The chapter has four parts. The first, the philosophical, provides a critical analysis of the term "emotion." The second and third parts show how that analysis helps us understand the relation between emotion and engineering. It explicates what a reasonable emotion is. In short, these two sections are organized around an ethical problem concerning management's rejection of engineering judgment. The fourth part, the pedagogical, delineates how we should develop a curriculum for a course

in engineering ethics. It suggests teachers of engineering ethics courses should take time in class to help students accept the fact that engineering has an emotional side, for example, that doing good engineering is likely to delight them and doing bad engineering to depress them. Lastly, it discusses the significance of emotions in the engineering decision-making process.

Chapter 2 discusses how the concept of social practice was introduced by Alisdair Macintyre as a means for ethical reflections for professional situations. This concept has been extended by Hoogland and Jochemsen to include different types of norms. The term "normative practice" indicates that practices are determined by the norms by which they are defined. Engineering is such a normative practice, one that is part of a more complex situation of technological developments, in which other normative practices are also involved (e.g., a government practice, a business practice, a consumer practice). The norms in a normative practice are not only ethical norms but also include task descriptions. In this chapter, the role of both non-ethical and ethical norms in engineering as normative practices is analyzed. This is illustrated by two case studies: one from military ethics (with a specific focus on the role of technology) and one from synthetic biology.

Chapter 3 elucidates engineering's primal goal, to do and invent. Today's engineering, as the motive force of technology, has reached pressing new ethical issues. The objective of this chapter is to explain the role of engineering ethics in technological design. This chapter concentrates on ethical issues that have a direct influence on the design of a product and the way it is used. In general, it focuses on ethical issues concerning safety and sustainability.

Chapter 4 discusses, besides respecting relevant codes of professional ethics, how engineers should heed the principles of common morality and international law, including the Precautionary Principle, which requires action to prevent serious or irreversible harm in advance of scientific consensus, when reasons exist to credit such harm. In this chapter, this principle is shown to be applicable to many kinds of technology. An objection that seeks to assimilate it to policies of Maximin is shown to miscarry. The principle is further interpreted as concerning avoidable reductions of future quality of life. The phenomenon of anthropogenic climate change is then shown to involve challenges for engineers. In addition to principles of justice and of benevolence, the Precautionary Principle is found to be relevant once again to such decision making. Finally, considerations of humanity's limited carbon budget are adduced to indicate, in the light of these principles, the inappropriateness of extreme forms of energy extraction.

Chapter 5 examines understanding engineering ethics in terms of three principles—but then going beyond ethics to political theory. A simplified prefatory comparison between engineering and science points to the importance of ethics in engineering. Section 1 provides a historico-philosophical overview of engineering ethics in the United States, on the premise that American experience can be generally illuminating. The narrative traces a trajectory of commitments from company loyalty to public responsibility, with the public responsibility promoting public engagement. Section 2 considers three influential American cases that together suggest a duty to public disclosure. Section 3 broadens the analysis through selective reviews of engineering ethics profiles in Germany, The Netherlands, Japan, Chile, and in transnational professional engineering organizations, on the basis of which is articulated a duty not only to avoid harm but also to do good. Section 4, a critical reflection on engineering in the intensive form of research and design, posits a synthesis of the principles of participation, disclosure, and beneficence into a duty *plus respicare*, to take more into account. A concluding section nevertheless suggests the inadequacy of limiting engineering ethics to ethics. Ethics in engineering like ethics generally implicates political theory. Ethics in the absence of politics demands unrealistic personal heroism; political theory without any foundation in ethics promotes tyranny.

Chapter 6 exhibits that engineers are observed as an archetype of people who carry out their professional tasks through rationality and quantitative aptitude. Thus, they do not consider themselves responsible for any sort of consequences their designed products have. But in contrast to their claim, many scholars argue that engineering products cannot be judged as value neutral as they are designed for public use. The product is good when people use it and get benefit from it and bad when tragedy occurs. The tragedy can be abated or possibly avoided if engineers would incorporate Emotional Intelligence (EI) into their professional task. EI is defined as "skills" that subsume self-awareness, self-regulation, motivation, empathy, and social skills. Thus, not incorporating EI in the engineering task brings about unwanted tragedies. Against this backdrop, this chapter critically examines the salient features of EI, three models of EI, significance of integrating EI into engineering design, methods to learn and develop EI, and ethical implications of EI in engineering profession.

Chapter 7 elucidates the underpinning relation among religious ethics, general ethics, and engineering ethics. We, the human beings, belong to one religion or the other by birth and/or by practice. There is hardly any society that is non-religious, and every major religion has religion-based ethics. Every evolved religion promotes values such as honesty, truthfulness, nonviolence, helping the needy, etc. These values are developed by major religions, such as Hinduism, Christianity, Islam, Buddhism, Jainism, etc. All these values together constitute our understanding about general ethics. Fortunately, many religions prescribe similar values, and these values are considered as general ethics, which the chapter delineates in detail. The chapter also elucidates why we have not considered agnostics' and atheists' views on religious ethics even if general ethical principles are based on religious ethics. Further, what is the need to have professional ethics such as engineering ethics when we already have religious and general ethics? The chapter argues "engineering ethics" as a professional ethics would be an autonomous system and would be independent of religious ethics and general ethics. The reason for this claim is professionals need to perform their duties in accordance with their professional codes of conduct, and not based on their religious ethics or general ethics. The chapter submits that engineering ethics is an autonomous ethics even if it has values that resemble religious or general ethics.

Here, the first section ends and second section begins with a title "Education." This section comprises six chapters ranging from Chapter 8 to 13. It addresses how "professional ethics" course should be integrated into engineering education, so that engineers can innovate humane technologies.

Chapter 8 as a leading chapter in this section suggests that "engineering ethics" is an area of academic study and focuses primarily on practical ethical issues. A primary aim of the study of practical ethics is to help students make good ethical decisions in whatever practical endeavors they may undertake, including in their chosen careers. The authors argue that reflection on the sorts of ethical problems that arise in engineering practice should be the starting point, with ethical theory coming into view primarily in this context. This is in contrast to a more "top-down" approach that tries to "apply" theory to practice only after laying out a spectrum of philosophically grounded theories, each of which attempts to give us a comprehensive picture of ethics, as such.

Like 19th century British philosopher Henry Sidgwick, the authors advocate first seeking common points of agreement and shared values at the level of everyday common sense. Invoking theories that attempt to "get to the bottom of things" can provoke unnecessary disagreement that gets in the way of constructive resolution of ethical problems that do not require agreement at the foundational level of our philosophical or religious thinking. Instead, we should content ourselves, for the most part, with employing our shared values at the level of everyday, common morality.

Chapter 9 illustrates that most engineering colleges in India have integrated ethics courses into their curriculum for the reason that students may develop an ethical ability to engage in sound decision making. However, there are differences noticed in defining the concept of "ethics" by the engineering students and the teachers who teach them ethics. Often, it is observed that students' positions with regard to ethics courses are egoistic pragmatism while the teachers follow idealistic pragmatism. This ideological difference makes teaching ethics to engineering students a difficult task and thus undermines the effectiveness of the ethics course. The major objective of this chapter therefore is to examine the extent to which the "gap" can be merged and make the students more ethically responsible. It also helps to achieve more job satisfaction for teachers. Finally, the chapter discusses some suggestions to make engineering students more ethically sensible.

Chapter 10 elucidates the importance of engineering ethics education in engineering programmes, involving major elements that build ethics education. Definitions and concepts of engineering ethics are introduced, along with an engineering code of ethics. Ethical education in engineering programmes is analyzed, focusing on teaching approaches and the effect of science and technological development on engineering socio-ethical issues. Survey results are presented, which illustrate students' attitudes toward engineering ethics, where it is found that students' attitudes were poor. Some strategies are suggested to improve engineering ethical education in engineering programmes.

Chapter 11 discusses that engineering students are introduced to their profession's ethical and social responsibilities along with their education and training at university. This might be the only time and place where public welfare engagement may be promoted by the institution and acknowledged by students. Their future behavior as engineers heavily depends on the understanding and commitment they may develop during this process. The purpose of this chapter is to discuss the main points related to the teaching and learning of Engineering Ethics at universities. In order to gain insight into this complex educational scene, a set of questions are formulated and explored. The discussion of these questions amounts to explain what Engineering Education consists of, how to integrate Engineering Ethics courses into the curriculum and develop instructional designs for classroom teaching, who should assume teaching responsibilities, and finally, what Engineering Ethics goals should be. For each query, the primal issues, controversies, and alternatives are discussed.

Chapter 12 explores the necessity of teaching ethics as part of engineering education based on the gaps between learning "hard" knowledge and "soft" skills in the current educational system. They discuss why the nature of engineering practices makes it difficult to look beyond dealing with engineering design problems, identify the difference between knowledge and risk perceptions, and how to manage such tensions. They also explore the importance of developing moral responsibilities of engineers and the need to humanize technology and engineering, as technological products are not value neutral. With a focus on Problem-Based Learning (PBL), the authors examine why engineers need to incorporate ethical codes in their decision-making process and professional tasks. Finally, they discuss how to build creative learning environments that can support attaining the objectives of engineering education.

Chapter 13 discusses ethical theories and their significance to Engineering Ethics and relevant and significant case studies of international and national import for future technological designs. Further, the importance of including social and moral values in the engineering design process and the advantages of abiding by the professional ethics code in Mechanical Engineering are also discussed. At the end, the chapter discusses the best way to teach an Engineering Ethics course.

The third section begins from here. This section is named as "Practice/Execution" keeping in mind the essence of the included chapters. It consists of four chapters and each chapter deals with the relevance and worth of using professional codes of ethics in engineering tasks. Chapters 14 to 17 form this section.

Chapter 14 focuses on the micro-level ethical conduct that materializes in face-to-face interaction in engineering teams. The chapter serves three aims: first, it defines the key concepts employed in the discussion. Second, it offers an account of the worth and impacts of investments in emotive skills in the engineering world. Finally, it describes a pedagogic experiment in incorporating ethics into engineering degree studies at Aalto University, Finland. The ultimate objective is to propose a teaching practice that would turn the currently marginal attempts to include ethical topics in engineers' syllabi into a mainstream mindset and philosophy that dictates decisions and drives conduct in future engineering communities.

Chapter 15: As an introduction to recognizing individual and organizational conflict as well as ethical issues within global firms, the goals of this chapter are to equip Science, Technology, Engineering, and Mathematics (STEM) professionals, especially those in engineering, with solid decision-making tools, including self-awareness, ethical perspectives and theories, ethical decision-making models, and various conflict resolution approaches. Given the current challenges in business and industry that have often led to unethical practices, and ultimately conflict, it is critical that both organizational leaders and followers possess the necessary tools and perspectives to create an ethical climate that deals appropriately with various types of conflict. This chapter examines new trends in conflict coaching and the delivery of ethics training in an effort to provide the aforementioned tools and perspectives.

Chapter 16 discusses how the difficulties inherent in the nature of software as an intangible object pose problems for specifying its needs, predicting overall behavior or impact on users, and therefore on defining the ethical questions that are involved in software development. Whereas software engineering drew from older engineering disciplines for process and practice development, culminating in the IEEE/ACM Professional Code in 1999, the topic of Software Engineering Ethics is entwined with Computer Science, and developments in Computer and Information Ethics. Contemporary issues in engineering ethics such as globalization have raised questions for software engineers about computer crime, civil liberties, open access, digital divide, etc. Similarly, computer-related ethics is becoming increasingly important for engineering ethics because of the dominance of computers in modern engineering practice. This is not to say that software engineers should consider everything, but the diversity of ethical issues presents a challenge to the approach of accumulating resources that many ethicists maintain can be overcome by developing critical thinking skills as part of technical training courses. This chapter explores critical pedagogies in the context of student outreach activities such as service learning projects and considers their potential in broadening software engineering ethics education. The practical emphasis in critical pedagogy can allow students to link specific software design decisions and ethical positions, which can perhaps transform both student and teacher into persons more curious about their individual contribution to the public good and more conscious of their agency to change the conditions around them. After all, they share with everyone else a basic human desire to survive and flourish.

Chapter 17 illustrates an issue that in recent years, it has become common for users to participate in the development of new technologies for health and quality of life. This development requires ethical issues to be taken into account. In this chapter, the researchers review the important recommendations and directives both worldwide and in European legislation in order to guide technological researchers. All research with human participants that poses any risk to them must be supervised by an external multidisciplinary entity. In addition, the participants must decide whether or not they want to participate, having been provided with all the information about the experiments and the risks of taking part. The privacy of the participants' personal data is another important issue.

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Section 1
Philosophy

Chapter 1
Engineers, Emotions, and Ethics

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ABSTRACT

This chapter tries to answer the question: What part, if any, should emotion have in making engineering decisions? The chapter is, in effect, a critical examination of the view, common even among engineers, that a good engineer is not only accurate, laconic, orderly, and practical but also free of emotion. The chapter has four parts. The first, the philosophical, provides a critical analysis of the term "emotion." The second and third parts show how that analysis helps us understand the relation between emotion and engineering. It explicates what a reasonable emotion is. In short, these two sections are organized around an ethical problem concerning management's rejection of engineering judgment. The fourth part, the pedagogical, delineates how we should develop a curriculum for a course in engineering ethics. It suggests teachers of engineering ethics courses should take time in class to help students accept the fact that engineering has an emotional side, for example, that doing good engineering is likely to delight them and doing bad engineering to depress them. Lastly, it discusses the significance of emotions in the engineering decision-making process.

Mr Spock: Interesting. You Earth people glorify organized violence for 40 centuries, but you imprison those who employ it privately.

Dr McCoy: And, of course, your people found an answer?

Mr Spock: We [Vulcans] disposed of emotion, Doctor. Where there is no emotion, there is no motive for violence. —Star Trek (First Season), "Dagger of the Mind", November 3, 1966

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Spock is probably an engineer (in today's sense).[1] In addition to high rank in a graduating class of Starfleet Academy, there are at least two reasons to think so. First, though he is nominally the USS Enterprise's "Science Officer", much of what Spock does looks like engineering rather than science. For example, he invents devices to order. Second, he is the opposite of the "mad scientist". He is accurate, cool, laconic, orderly, and practical. He prefers fact to imagination, calculation to hope. Spock presents himself as an agent of reason in a world that emotion might otherwise overthrow. He embodies an ideal to which many of my engineering students, includ-

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ing many of the women, feel attracted. Indeed, most practicing engineers I know have stories in which they present themselves in just this way, for example, when they have had to explain why the heat pump that Marketing promised a customer cannot be built: the specifications violate the first law of thermodynamics. The engineer had to say (something like), "Whatever Marketing would like, no amount of inspiration, team-building, incentivization, or even budget can make these specifications a reality."

Yet, there are at least two reasons to doubt that Spock is the proper ideal for engineers. The first is that Spock is only half human, biology inexplicably allowing for a Vulcan father. He is an outsider among humans as well as Vulcans. Of course, the popular view of engineers as "nerds", "dweebs", or "geeks" suggests something similar. Nonetheless, all the engineers we have (or are likely to get any time soon) are human; they worry, hope, love, and otherwise have an emotional life much like the rest of us. They are not even half Vulcan.

Second, there is the question whether even full-blooded Vulcans could have (as Spock put it) "disposed of emotion". How we answer that question must, of course, depend (at least in part) on what we mean by "emotion". Much the same dependence exists when we ask about the place emotion should have in engineering. What I shall argue here is that, on the most defensible definition of "emotion", emotion is unavoidable in engineering – and, indeed, in life generally – not as an evil, but as positive good. Even Vulcans must have emotions in this sense – and, on the whole, would be better for it. Although Spock may be right that "where there is no emotion, there is no motive for violence", he can be right only if it is also true that where there is no emotion, there is no motive to do anything significant. Life without emotion is merely the mind's algorithms or the body's automatic functioning, hardly life at all. The problem for engineers, as for all humans and Vulcans, is not to do without emotions but to have the right emotions – at the right time, to the right degree, in the right way, and directed toward the right object. Not only is this true of emotion in the most defensible sense but even in some popular but less defensible senses.

This chapter has four parts. The first, the philosophical, provides an analysis of emotion in sufficient detail for our purpose, sketching a defense of that analysis along the way. The second and third parts show how that analysis helps us understand the relation between emotion and engineering. The fourth, the pedagogical, briefly considers how the analysis might help to structure a course in engineering ethics.

I shall say nothing here about what is now often called "emotional intelligence", that is, the ability to monitor one's own and others' emotions, to discriminate among them, and to use that information to guide one's thinking and actions (Mayer, DiPaolo, & Salovey, 1990, p. 189). My subject is having emotions, not knowing about them. How important having emotions is to having the corresponding intelligence is another question I shall not address here.

I shall also try to say as little as possible about other psychological states, such as moods and intuitions. Whatever their interest to philosophers of mind, they are beyond the focus of this chapter.

I. DEFINING EMOTION

What then is emotion? If we define emotion as "a strong feeling, such as anger, fear, joy, love, or revulsion" (as many dictionaries do), Spock may be right. We can imagine something like a human life without strong feelings – and so, perhaps, without violence.[2] There are nonetheless at least four objections to this popular way of defining emotion. The first is that it creates a problem of measurement. Even assuming we had an "emotion meter" (as we may soon have), we would still have the problem of deciding how strong a feeling like anger or fear must be before it is strong enough to count as "strong". Presumably, a feeling

strong enough to overcome reason (what used to be called "a passion") would be strong enough to count as an emotion in this sense. But using that criterion would define reasonable emotions out of existence (making "emotion" a mere synonym for "passion").[3] We seem to think that some emotions, such as horror upon seeing a young child cruelly killed, are, though very strong feelings, quite reasonable, indeed, appropriate, and their absence a sign of a damaged psyche.[4] Of course, it is not good for even such reasonable emotions to "overcome reason". But that is a point distinct from whether the feeling in question is strong. We should try not to decide by definition what seems to be an empirical question, for example, whether even a weak feeling could overcome reason or even a very strong feeling be reasonable.

What would constitute an emotion on the overcoming reason way of measuring strength would, of course, depend on how we defined "reason". Defining "reason" is itself a major problem in philosophy, a problem we should avoid here if we can.[5]

A second objection to the strong feeling way of defining emotion is that even the avoidance of emotion (so defined) is not obviously desirable. The world such avoidance would create would be a world of irritation but not anger, timidity falling short of fear, thin joys, "love" that is hardly more than lukewarm affection, disgust but not revulsion, and so on. Life in a world without emotion (so defined) seems deeply impoverished (explaining, perhaps, why the very human Captain Kirk, not Spock, is the protagonist of the early *Star Trek*).

A third objection to defining "emotion" as strong feeling is that so doing seems to exclude many gentler feelings commonly counted as emotions, for example, boredom, contentment, curiosity, liking, and regret. The strong feeling definition seems designed to catch the pejorative use of "emotion" – as in "Don't be so emotional" – but to ignore many emotions that have an important place in life – Vulcan as well as human.[6] (After all, Spock's father, though entirely Vulcan, must have felt strongly about Spock's human mother, since he married her despite much Vulcan prejudice.)

A fourth objection to the strong feeling definition is that it fails to connect emotion to action. Yet, even on Spock's understanding of emotion, emotions have a connection with action. Disposing of emotion is, after all, according to Spock, the way to end violence. That end to violence is possible only if emotions are causes or reasons for violent action. Not all feelings are causes of or reasons for action. Some, such as those one has when dreaming, are simply feelings.

I therefore suggest we adopt the following definition of emotion instead: *emotion is any feeling that is a reason to act (or refrain from acting)*. By feeling, I mean (roughly) any conscious mental state that includes both a) a mental representation (for example, "this pump is broken") and b) a positive, negative, or indifferent response to that representation (for example, attraction or distaste). Given this pair of definitions, some pleasures and some pains are emotions, whereas others are not. For example, the pain I feel upon seeing my son hurt is an emotion; but the immediate pain I feel when I accidentally hit my finger with a hammer is not. The first includes a mental representation ("my son is in pain"); the second does not, producing instead an automatic response (a cry of pain, the bruised finger moving toward my mouth, and so on). The pain of the bruised finger is not, strictly speaking, even a feeling but (we might say) a physiological shock or eruption (until I calm down enough to realize what has happened). Because emotion is a kind of feeling, there can be no unconscious emotions (unless feelings can also be unconscious). The unconscious, insofar as it motivates, will have to be the domain of other kinds of motives.

Emotions are reasons for acting in two senses. First, we can *explain* an action by pointing to an emotion, for example, "She protected George because she likes him." Liking George moved her to protect him, whether she realized it or not. Explanations, though typically offered by someone

other than the agent, may also be offered by the agent (though the agent must then view herself as others do). Second, emotions may be reasons for acting in the sense of providing a *justification* for an action, for example, "I am protecting George because I like him." Justifications, though typically something the agent offers, may be offered by another (though that other must understand the action from the agent's perspective).

Even a good explanation may not show that the act in question is reasonable to do, only reasonable to expect. In contrast, justifications have a closer connection with reason, that is, with what all reasonable people would (at their rational best) do, encourage, or at least allow. A good justification succeeds in making such a connection; a bad one tries but somehow fails. So, for example, although love may justify marriage, it cannot (all else equal) justify murder. "I murdered for love" is a justification only in the way counterfeit money is money; it cannot (all else equal) be a good justification, only something that improperly seeks to pass for one.

An emotion may, or may not, arise from its dispositional equivalent. So, for example, fearlessness is an emotion corresponding to the disposition to be fearless. Yet, those who are fearless at a given time (that is, act from a conscious indifference to harm) may not have the equivalent disposition. One can be fearless once in a lifetime and fearful the rest of it. That seems unlikely as a matter of psychology, of course, but not impossible. A particular emotion need not arise from a particular disposition.

An emotion does not necessarily have an equivalent or mirroring virtue (as, say, feeling curious mirrors the virtue of curiosity). An emotion may fail to mirror a virtue in at least one of two ways. First, some emotions fail because they are not good. For example, the emotion of jealousy is never justified; boredom, even when justified, mirrors no virtue (since there is nothing virtuous about being bored). To be a virtue, a disposition must dispose one to good acts rather than to bad or indifferent ones. Second, some virtues fail to mirror an emotion because the virtue in question requires more than a disposition to have a simple feeling. For example, although courage is a virtue, it does not mirror the feeling of courageousness. Courage is reasonable conduct in the face of fear. The courageous person must feel fear. Anyone who does not feel fear cannot be courageous, only fearless. What counts as "feeling courageous" is typically a kind of fearlessness or even foolhardiness. Fear is the emotion that courage requires, the same emotion that its opposite, cowardice, requires. The virtue of courage has no emotional equivalent.

One last point. An emotion is a reason to act but not necessarily a decisive reason. One may have the appropriate emotion in a situation and yet not act on it or even be justified in acting on it. One may, for example, feel hostility and yet act kindly – and be justified in so doing – when, say, one has a debt of gratitude. In such cases, one emotion (gratitude) may trump another (hostility). One may also act from motives that are not emotions, such as habit, prudence, or convenience. Emotions are not the only reasons to act (in either the explanation or justification sense).

Given this understanding of emotion, an engineer – even a Vulcan engineer – seems unlikely to be able to do much without emotions. So, for example, we want our engineers, even our Vulcan engineers, to be courageous and courage requires an emotion (though fear rather than the feeling of courageousness). We do not want our engineers to be merely fearless (as an emotionless Vulcan would have to be).

What if someone objected that Vulcans might get by with the appropriate attitudes without the corresponding emotions? Vulcans might, for example, have a fearful attitude without ever feeling fear. The attitude (a settled way of thinking or feeling) would, I shall assume, truly be theirs, not a mere stance or pretense. If so, then a fearful attitude must exist in part at least as a disposition to feel fear on appropriate occasions. Why even

speak of a "fearful attitude" if it is never expressed in emotions, that is, in moments when the fear is felt? Crucial to having a certain attitude is the tendency to have certain emotions on certain occasions. Attitude is not a substitute for emotion.

II. THE EMOTIONAL LIFE OF A GOOD ENGINEER

Having established that even Vulcan engineers cannot do without emotions, we must now consider what part emotions should play in engineering. To avoid seeming to have made that project easier than it should be, let us focus on the strong feeling kind of emotion. What part, if any, should such feelings as anger, fear, joy, love, and revulsion have in the professional work of ordinary engineers? Consider this case:

Your employer, Passable Electronics, asked you to design a "reclamation facility" for waste from its Chicago plant. Though the facility will be located in the Republic of Cameroon, a central African country of about 20 million people, you, a civil engineer, designed the facility to meet the same standards it would have to meet if located in the United States. The US standards are, in part, meant a) to protect workers from suffering injury from contact with heavy metals and other toxins present in the wastes to be recycled and b) to prevent the processed or dumped heavy metals and other toxins from entering the air, ground water, or water table in the neighborhood of the facility. When you present your design to senior management, they object to the cost, ask you what Cameroon requires, and – upon hearing "practically nothing" – suggest meeting only the local standards. "After all," they add, "Cameroon needs the jobs and following US standards will make processing the waste there more expensive than processing it here, depriving the Cameroonians of jobs. The low wages there are more than enough to compensate for shipping the waste so far but not if we meet US standards of disposal." You point out that doing as management asks would mean at least 30 otherwise unanticipated deaths annually among the workers and neighbors of the facility during the facility's projected useful life and perhaps for several decades after that. Most of those deaths would be from poisoning of one sort or another. There would also be considerable environmental damage locally, much of it irreversible. Management responds, "That's their problem, not ours, as long as we satisfy US and Cameroon law and provide Cameroon's government with whatever information it requires to assess the risks."

When I pose this case to working engineers, the initial response is typically a frown (a sign of unhappiness). Some engineers will go on to give more explicit signs of unhappiness. One might say, "It's their money and I'll do it, if I can't change their mind, but it's not work I can be proud of." Another might say, "What they're asking for is not engineering but murder. I'd refuse to do as asked." Still another might say, "I'd add the cost-savings required to the specifications and see what I could come up with." All three responses, even the first, seem reasonable, although a happy-to-do-whatever-you-want response does not. A good engineer is an engineer who cares about doing good engineering; the more he cares about that, the better an engineer he is (all else equal). An engineer who cares only about doing whatever his employer asks is not a good engineer. Few, if any, engineers, would view what management asks here as good engineering.

If what I just said sounds right, then we have found one place for strong emotions in engineering. A good engineer has a strong (positive) feeling about how engineering should be done, a feeling justifiably capable of affecting how she does her work. Indeed, we might say that caring a lot about engineering is part of what *constitutes* a good engineer. An engineer who cares little or nothing about engineering is not a good engineer – even if she desperately wants to keep her job, do what

management wants, and so on. Though there may be empirical evidence for this connection between caring and being a good engineer, the connection is, I think, primarily conceptual. Although we may be able to imagine an engineer who does not care about engineering but, from other motives, does reasonably good engineering, we – or, at least, the engineers among us – may nonetheless hesitate to call her "a good engineer". She seems, at best, the functional equivalent of a good engineer – one whose good luck is unlikely to last for long. (For empirical evidence for the connection between caring and doing a good job, see, for example: Gaudine & Thorne, 2001; Roeser, 2012.)

Are there any other strong emotions that help to constitute a good engineer? I think so. I'll give one example here (fear), leaving it to my readers to add to the list. A good engineer will fear the bad consequences of his work, especially when the bad consequences could include substantial loss of life or property. By "fear", I mean a strong negative response to an anticipated harm. A weak negative response is a mere concern or caution, an overwhelming response, fright or terror. An engineer who fears every harm his work may produce is unreasonable. There is no engineering without harm. The proper emotional response to the prospect of some harms – the minor or socially tolerated ones – is concern or caution, not fear. Fear is the proper response to the larger or unusual harms, especially if they are relatively probable and poorly understood. A strong negative feeling in response to the prospect of such a harm is fear – by definition.

Some emotions are part of what constitutes a good engineer. Are there any emotions that, though not constitutive of a good engineer, are still good for engineers to have *on occasion*? That is not an easy question to answer convincingly because there is a tendency to include in the concept of a good engineer everything that might be good for an engineer to have. Before we can confidently point to an emotion that is good to have but not part of what constitutes a good engineer, we need a criterion for distinguishing the constitutive from the merely good or useful to have. I do not now have such a criterion. I shall nonetheless offer an example of an emotion that seems to me to be good for engineers to have on occasion but not to be part of what constitutes a good engineer. Before doing that, however, I should point out that nothing important for this chapter turns on the example. If I am wrong, and the emotion is constitutive of a good engineer rather than just good for an engineer to have, the example will still add to the list of emotions appropriate for engineers to have, strengthening this chapter's claim that emotions have a central place in engineering.

The emotion that I shall put forward as one good for engineers to have on occasion but not constitutive of a good engineer is anger. By "anger", I mean the feeling that someone has been wronged, slighted, or otherwise improperly checked, together with the desire to strike back. One may be angry on another's behalf as well as on one's own. Humans show anger by, for example, speaking louder than usual, cursing, baring their teeth, and staring. We can, I think, imagine an engineer who, though obviously a good engineer, never feels anger in professional work (someone like Spock, perhaps).

It would, nonetheless, be reasonable for an engineer to be angry if management rejected her design for the waste facility in Cameroon for the reasons given above. Indeed, it seems right to interpret the second engineer's response, "What they're asking for is not engineering but murder", as a clear expression of anger. It is reasonable for an engineer to be angry under such circumstances insofar as a) she is in fact being wronged (her professional judgment is being improperly discounted) and b) it is important for management to appreciate the resulting desire to strike back. It is important for management to appreciate that retributive desire insofar as it is a cost not included in the original calculation. The engineer's anger, once expressed, would then itself become a reason for management to revise its decision. Indeed,

it would be reasonable for management to take into account not only the fact that the engineer is angry but how angry she is, how she is likely to strike back, and how much support she may find among other engineers, other employees, and even the world outside Passable Electronics.

More important, I think, is that the anger would in fact help management appreciate the weight that the engineer's judgment itself deserves. All else equal, the more serious the affront to his standards of engineering, the angrier the engineer should be ("should" here including both explanation and justification). The more serious the affront, the less likely that management's reasons for overriding his engineering judgment are adequate. Much that engineers are hired for is not calculation, deduction, or other algorithmic activities. Much of engineering is a matter of judgment, something hard for non-engineers to evaluate. The emotion that engineers express is one way, an important way, to communicate what is at stake in management's decision to override an engineer's judgment. (For more on engineering judgment, see Davis, 2012.)

Anger has its own costs, of course. The most obvious is that one typical response to anger is anger, with one display of anger leading to another, until someone – as we say – "loses his temper" and there is a break in relations (for example, the violence that the Vulcans were supposed to have escaped). One way to avoid such a break is to adopt the first engineer's approach, that is, try to change management's mind by calm argument and, failing that, shrug and do what's asked. That way avoids the risks of escalating anger but also abandons anger's power to communicate. Another way to avoid such a break in relations is to try to find a creative way out of what now seems a true dilemma (as the third engineer proposed to do). That is doubtless the best approach for an engineer to take, especially initially. If it works, there is no longer a problem. If, however, it does not work, the first and second approaches are still options. A show of anger may then be a reasonable response, indeed, given what's at stake – considerable loss of life and property and damage to the environment – a response more reasonable than a mere shrug.

III. EMOTIONS AND ENGINEERING ETHICS

From what I have said in the last section, it should already be clear that emotions have a place in engineering ethics, indeed, at least three places. First, some emotions, primarily those that are in part constitutive of a good engineer, help engineers appreciate what they're doing. So, for example, if – after checking the facts – contemplating an outcome of a design causes an engineer dread, worry, or even mere discomfort, the engineer should certainly try to revise the design to remove that outcome. Similarly, if an engineer takes pleasure in contemplating a certain design, that pleasure is itself a reason to favor the design. Insofar as engineering judgment tracks engineering's ethical standards (as well as its technical standards), emotions contribute to an engineer's ethical sensitivity.

Second, the strength of an emotion may provide a measure of the considerations provoking the emotion. All else equal, the stronger the emotion, the greater weight the provoking considerations should have in the engineer's deliberations. Insofar as the considerations in question are ethical (for example, loss of life or property), the strength of the emotion should provide a reasonable measure of ethical importance.

Third, emotion has a place in the communication of engineering judgment. My examples so far probably suggest that emotion only has a place in communication between engineers and non-engineers. Actually, I think emotion has a similar place in many communications between engineers. Although one engineer can sometimes see through another engineer's judgment to the underlying evidence that supports it, perhaps more often she cannot. Even another engineer may lack the experience, ability, time, or special training

necessary fully to absorb the relevant evidence. When an engineer cannot see through another engineer's judgment to weigh the underlying evidence, how the engineer presents the judgment may matter a good deal. Confidence is evidence for the judgment; signs of concern, evidence against; and so on. Of course, engineers should be careful not to give a false impression. They should not try to hide their pride or fear, for example. Hiding such emotions is much like making deceptive statements about their judgment.

Here perhaps is the place to say a bit more about the distinction between having an emotion and displaying it. Most humans have difficulty having an emotion without displaying some signs of it. Most also have difficulty giving the appearance of an emotion without actually having it. Although actors seem to be able to give the impression of emotions without having them, most of us are not good actors. And even good actors may not be that good. Many actors seem fake off stage, as if they are only playing at the emotions they seem to display. What counts as an authentic display of emotion on stage may fail to seem authentic off stage. So, the most likely effect of, for example, trying to hide one's anger is to make the anger seem weaker than it actually is, misleading those who are trying to evaluate the seriousness of what one is saying at least in part by how one is saying it. "Try to hide your emotions" is seldom a prescription for successful communication.

The control of emotion – assuring that we have the right emotion at the right time, to the right degree, in the right way, and directed toward the right object – is probably best accomplished by vividly confronting the emotion in question with the relevant facts long enough for the facts to sink in, produce reflection, and mature into a plan. A reasonable emotion is one that can survive vivid contact with all the relevant facts. (Compare Brandt, 1979, p. 148.)

IV. PEDAGOGICAL CONCLUSIONS

Given what I have said so far, it seems to me that teachers of engineering ethics should take time in class to help students accept the fact that engineering has an emotional side, for example, that doing good engineering is likely to delight them and doing bad engineering to depress them. They should also be taught to use their discomfort with what they are doing to help identify ethical issues. They should not, of course, be allowed to let their "gut response" be decisive. We all know what fills the gut. An uncomfortable gut is nonetheless a good reason to think again, gather more information, and so on. The "gut" is like one of those "pretty good" sensors that engineers use with considerably less than total trust – but use nonetheless while they lack anything better (Mayer, DiPaolo, & Salovey, 1990). Similarly, students should be given practice turning their reasonable emotions into plausible arguments, for example, by learning to explain the place of engineering judgment in good engineering.[7]

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KEY TERMS AND DEFINITIONS

Curriculum: The subjects defining a course of study in a school or college.

Emotion: Any feeling that is a reason to act (or refrain from acting).

Emotional Intelligence: The ability to monitor one's own and others' emotions, to discriminate among them, and to use that information to guide one's thinking and actions.

Engineering Decision: Any decision an engineer can make in part at least because she is an engineer (rather than, say, a parent, citizen, employee, or the like), whether or not the decision requires the special knowledge, skill, or judgment of an engineer.

Engineering Ethics: The special morally permissible standards of conduct that apply to engineers because they are engineers.

Ethics: Those morally permissible standards of conduct every member of a group wants every other member of the group to follow even if that means having to follow them too. Morality, in contrast, consists of standards applying to everyone, not just to members of some group.

ENDNOTES

[1] I am, I admit, not sure of my tense here. Since Spock is a character in a story set in the future, perhaps "will be" is more appropriate (though "will" suggests an actual future, not a fictional one). The past tense might also be appropriate because, from our perspective, the story has already played out (in a fictional future). One reason I feel obliged to comment on tense is that I recently visited Riverside, Iowa – "the future birthplace of Captain James T. Kirk", Spock's commander. Everyone there seemed to have trouble with tenses when discussing Kirk's childhood. Of course, concern with tense is mere pedantry here. My argument is independent of it.

[2] By "violence", I suppose Spock means (something like): using force in a way violating a moral rule. Murder, mayhem, kidnapping, and the like are all acts of violence. Justified self-defense is not (however much force proves necessary).

[3] This collapse of emotion into passion actually occurs in the scientific literature. For example, one introductory text in psychology defines "emotion" as "a disorganized response, largely visceral, resulting from the lack of an effective adjustment" (Schaffer, Gilmer, and Schoen, 1940, p. 505), quoted in Mayer, DiPaolo, & Salovey (1990), p. 185.

[4] For more on rational emotions, see, for example, Wallace (1993) or Davis (1986).

[5] For those who care, I think I may safely say this much about reason here. Reason as mere logic (for example, the avoidance of inconsistency), or mere instrument (for example, choosing means appropriate to one's ends, whatever ends one has) seems too narrow for our purposes. Few emotions are unreasonable in the logical or instrumental sense. We should, at a minimum, define "reason" as a capacity that rational beings have because (and insofar as) they are rational agents. Rationality in this sense includes: a) certain beliefs (such as that cutting off a man's head will kill him); b) certain values (such as preferring, all else equal, pleasure to pain, life to death, and opportunity to the lack of it); c) certain capacities (such as the capacity to plan taking into account one's beliefs and values); and d) certain ways of conducting oneself (such as acting upon one's plans). Note that, unlike the logical or instrumental definition, this relatively rich definition of rationality does not make reason the slave of the passions (as Hume put it). Given this definition, Hume was plainly wrong when he claimed, "Tis not contrary to reason to prefer the destruction of the whole world to the scratching of my

finger." Hume (1739), Bk. II, Pt. III, Sec. III. Given this definition, the loss of the world is worse than a scratch to one's finger. That is one reason to accept (something like this definition). As a matter of common sense, one would have to be crazy (or in the clutches of the logical or instrumental definition of "reason") to accept Hume's claim.

6 Literally, the expression "so emotional" leaves open the possibility that less emotion would be okay even if much more than no emotion. Idiomatically, however, the expression seems to carry the message that no emotional response would be best – as do such similar expressions as "Cool it", "Get a grip on yourself", and "Think with your head, not your heart".

7 For examples of how this might be done, see (among others): Heikkerö (2008); Molewijk, Kleinlugtenbelt, and Widdershoven (2011); or Sunderland (2014).

Chapter 2
Engineering as Normative Practice:
Ethical Reflections on Tasks and Responsibilities

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ABSTRACT

The concept of social practice was introduced by Alisdair Macintyre as a means for ethical reflections for professional situations. This concept has been extended by Hoogland and Jochemsen to include different types of norms. The term "normative practice" indicates that practices are determined by the norms by which they are defined. Engineering is such a normative practice, one that is part of a more complex situation of technological developments, in which other normative practices are also involved (e.g., a government practice, a business practice, a consumer practice). The norms in a normative practice are not only ethical norms but also include task descriptions. In this chapter, the role of both non-ethical and ethical norms in engineering as normative practices is analyzed. This is illustrated by two case studies: one from military ethics (with a specific focus on the role of technology) and one from synthetic biology.

INTRODUCTION

Engineering is an increasingly complex activity in which many actors are involved. One of the challenges in engineering ethics is the "many hands" problem: the complex interactions between different actors make it difficult to decide who is responsible for failures of the products of engineering. The famous Challenger case, which can be found in many textbooks for engineering ethics, is a classic illustration of that. Engineering, however, is not entirely unique for that. In the ethics of care a similar situation occurs. Patients, specialists, hospitals, insurance companies, governments and suppliers of medical equipment and medicines, to mention some of the major players, all interact in this field of activities. In the ethics of case, an analytical tool has been developed that can also be useful for engineering.

This tool builds upon the concept of social practices that was introduced by Alisdair Macintyre (MacIntyre, 1984). Macintyre developed

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this concept in the context of his virtue-ethical approach and refers to Aristotle's suggestion that ethical behavior can only be learnt in the practice of life. Macintyre goes on by pointing out that one needs to differentiate between different professional practices. What a "good human" would do, should be specified for a "good doctor", a "good teacher", a "good butcher", etc. What is a morally "good" rule in one practice may be not acceptable in a different practice (for instance, the butcher and the surgeon both cut meat, but the situations are morally quite different, so what is morally "good" in one case, may be unacceptable in the other). Macintyre's concept of social practice does not yet contain a typology of different norms. This was introduced by Hoogland and Jochemsen. They combined Macintyre's concept of social practices with some concepts that had been developed by Herman Dooyeweerd, a Dutch philosopher who was one of the founding fathers of the so-called reformational philosophy school, in which Hoogland and Jochemsen also can be situated. Their first domain of application was the ethics of care. In this chapter, their approach will be applied to the social practice of engineering. By looking at different types of norms, the concept of practices also is extended beyond the limitations of a virtue approach in ethics, as the norms can also be more Kantian in nature (duties) or refer to the need to avoid or strive towards certain consequences. For that reason, the Hoogland–Jochemsen approach to practices can be better characterized by the term "responsibility". It combines different ethical approaches by incorporating different types of norms. Also, it combines ethical and non-ethical (e.g., functional) norms and thus gives a wider perspective on the dilemmas with which actors in the practice are confronted. In the next section, the concept of "normative practices" will be described. In the sections following that, it will be applied to engineering.

THE CONCEPT OF NORMATIVE PRACTICES

In his analysis of social practices (although the term as such did not yet exist in his time), the Dutch philosopher Herman Dooyeweerd distinguished between the structure and the direction of that practice (Dooyeweerd, 1953). The difference between these two concepts can be illustrated by examining how a business corporation operates. The structure of the company indicates the various departments or divisions within such a company, each of which has certain tasks and responsibilities. In the well-known electronics company of Philips, for instance, there is a Board of Managers, a corporate laboratory (Philips Research; de Vries, 2005b) and a number of Product Divisions (one for medical equipment, one for audio and video consumer products, etc.), each of which has its own division laboratory and factories for production. Each of these components in the corporation has its own tasks and responsibilities and in the history of this company, a lot of debates have been ongoing about these. Decisions on how tasks and responsibilities are divided over the various departments defines the "structure" of the company. The direction has to do with the deeper values the company holds. These should be distinguished from the goals in the structure. Each Product Division has a task in bringing profit to the company, but this is more related to the fact that we are dealing with a company that can only exist when profit is made. This is not a choice, it is a necessary element in the structure of the company. Companies can, however, decide on deeper values. One company may, for instance, decide that pleasing the shareholders will be the ultimate value that directs all activities towards this ultimate concern. A different company may decide that the customer's values should be the primary concern for the company. "Customer first", could be a slogan for that company. Such higher values are often formulated in mission statements and strategy documents, whereas the

structure of the company is formulated in quality assurance documents.

This distinction can be used to define two types of norms: structural norms and directional norms. They form the structural, respectively, the directional side of a practice. An alternative way to make the same distinction is to refer to John Searle's distinction between constitutive and regulative rules (Searle, 1969). In the game of chess, the constitutive rules define what chess is. Anyone who trespasses against these rules does in fact, not play chess. But, one can play chess for different reasons. Some people do it just for pleasure and some do it to make money. In one case, winning can be the highest value, in another creating a good relationship with the other player as a friend can be the highest value (for which the goal of winning the game perhaps is even given up if the situation demands that). The constitutive rules are similar to the structural norms. Likewise, the regulative rules are similar to the directional norms. Thus, one can also speak of the constitutive and the regulative sides of a practice.

Within the category of the constitutive or structural side, different types of norms can be distinguished. Hoogland and Jochemsen introduced the following three types – qualifying norms, foundational norms and conditioning norms (Jochemsen, 2006; Hoogland & Jochemsen, 2000). The difference can again be illustrated by using the game of chess or the company. Qualifying norms refer to the primary function of the practice. In the game of chess, they are the rules that define when the game is won. Foundational norms are concerned with the moves that are allowed and those that are forbidden. Conditioning norms describe for instance the different chess pieces and the layout of the chess board. In the business corporation example, the qualitative norms are concerned with what is produced and how profit is made, the foundational norms define the tasks of the various departments, and the conditioning norms are concerned with, e.g., local/national/international legislative constraints. In summary, the different types of norms in the concept of a normative practice are:

1. Regulative
2. Constitutive
    a. Qualifying
    b. Foundational
    c. Conditioning

Another element in Dooyeweerd's philosophical analyses that can be applied in the concept of normative practices is his idea of "aspects" or "law-sides" of reality. Dooyeweerd noted that we can analyze reality in different ways. We can, for instance, focus on the numerical aspect of reality by measuring and counting what we see. This gives us useful information about reality, but this particular focus makes us also ignore other valuable aspects. We can make risk calculations, which is useful and informative, but does not yet take into account that there is also something like risk perception, which is difficult to catch in numbers. Likewise, one can examine the physical aspect of reality and reduce each and every event to the exchange of matter and energy. This, too, is informative, but does not include a lot of other aspects of the event, such as the pain one can feel in the case of a collision. This would be part of examining the psychic aspect of reality in which our experience of reality (knowing, feeling, observing, etc.) is the primary focus. We can also investigate how people ascribe economic values to entities, which leads to the approach of the economists. We can also do this for aesthetical value ascription. Ethics focuses on moral values that we adhere to people or activities. The final aspect in Dooyeweerd's approach is what he calls the pistic aspect of reality, which deals with the way we adhere "trust" or "belief" values. This is not only what religions do, but also what we all do when we decide to enter an aircraft without checking whether the pilot is sober and whether everything has been maintained properly in the past months. All of these aspects can be related to

one or more academic fields, such as mathematics, physics, psychology, economy, aesthetics and ethics. In total, Dooyeweerd identified fifteen of such aspects, but this number is in a way arbitrary and depends on practical needs for a particular analysis. The connection among these aspects of reality and the norms in a normative practice is that each norm is grounded in a certain aspect. The norm of making money is grounded in the economic aspect. The norm of legally forbidden materials in production is grounded in the legal aspect. The norm of transparency of products for customers is grounded in the psychic aspect. This way the aspects of reality give us a more detailed insight into the nature of the norms in the various types (constitutive, qualifying, foundational, and conditioning).

ENGINEERING AS A NORMATIVE PRACTICE

Actors in Technology

In STS (Science, Technology, Society) literature, it is often pointed out that technological developments take place in a network of actors (Latour, 2005). The normative practice concepts help to spell out the characteristics of those actors and understand why there are often tensions within the actor–networks. These tensions are related to ethical dilemmas. Four types of actors in technological developments are: industrial corporations, universities (of technology), governments and citizens/users.

Industrial corporations exist by producing goods or services. Their foundational norms are related to that. These norms are related to the formal structure of the company: which department is responsible for what? These norms are often laid out in a quality management system. The qualifying norms are related to the primary process, which is the ultimate goal of the company: making profit by making and selling products and services. Such norms deal with what the properties of the products and services should be, both technical and economical. Conditioning norms have to do with issues that facilitate and determine the primary process. One can think of norms for personnel that are to be hired, or norms that come from outside (for instance, legislation that says something about materials are forbidden). Directional norms can differ per corporation. One company may see the customers' satisfaction as the highest good, another company may see pleasing the shareholders as such.

Universities are there for producing knowledge that supports the technological developments. Their foundational norms are similar to the corporations' foundational norms: universities are organized in faculties and departments, each of which has their own tasks and responsibilities. The qualitative norms have to do with the knowledge that is produced. They can be the norms for what counts as evidence for a knowledge claim. Conditioning norms can be requirements set by journals or by funding agencies. Directional norms can differ here, too. Truth-finding is an obvious option, but making profit more and more tends to become one nowadays. The tensions emerging from the latter option show that not all directional norms fit well with the constitutive norms. Traditionally, universities were aimed at truth-finding and it is only because of economic stagnation or decline that universities are forced to regard money-making almost as its highest good. People working in research often experience this as an improper situation.

Governments are there to provide and maintain conditions for having a society in which justice and peace can prevail over violence and poverty. Their foundational norms are the various functions (presidents, ministers) and ministries each of which have their own tasks and responsibilities. Their qualifying norms are related to their primary processes: legislation, prosecution, providing economic incentives, etcetera. Conditioning norms can result from international agreements (EU

legislation for European countries, for instance). Directional norms again depend on what the government sees as its highest good. Some governments see holding power as such, alas. Other governments may see providing justice for all as their ultimate value.

Citizens are a complex normative practice, as many norms are not defined explicitly and it can even be questioned if citizens form one coherent normative practice, given the very different directional norms that different citizens hold. Therefore, this population often needs to be split up in sub-practices for a proper analysis. Older people may have different highest goods than younger people (having lived in poorer conditions may, for instance, have made them less focused on materialistic values), rich people may have other highest goods than poor people, there are people for whom personal comfort is the highest good and for others it is serving God or one's neighbor. Some citizens are committed to specific issues such as environment protection. They can be organized in more formal sub-practices such as Greenpeace. For sub-practices like that, there are explicit norms laid out in charters.

Interacting Practices

All the actors (practices) interact in technological developments. Governments have a say in what corporations, universities, and citizens do. What universities do has an impact on what corporations can produce and also on what citizens think. Business corporations have an impact on how citizens live, and co-determine whether or not universities have the necessary funds for doing research. The choices that citizens make cannot be ignored by business corporations and citizens determine (by voting) what the next government looks like, a minimum in terms of directional norms. These are just some of the interactions in the actor-networks in which technological developments take place. Now several types of tensions can occur.

In the first place, tensions can occur within any of the practices in the network. If, for instance, a university changes its direction from truth-finding to money-making, while keeping all constitutive norms the same, it can be expected that these norms do not fit well with the new direction. Researchers may find themselves in a dilemma, because the constitutive norms tell them to publish as much as they can in prestigious journals, but the directional norm of making money may force them to keep knowledge silent until a patent has been submitted or agreement has been reached with a business corporation about using the knowledge. A similar tension can occur in a corporate laboratory with a fundamental research focus (such as the Philips Research Labs in the 1960s and 1970s; De Vries, 2005b). Inconsistencies between norms within a practice may be among all types of norms, and even within the same type of norms (for instance, when the tasks and responsibilities of faculties in the same university have been defined inconsistently so that they overlap). Such dilemmas often result in ethical dilemmas. When in a business company the constitutive norm of profit-making pushed away the direction norm of caring for the users' safety (such as in the famous case of the Ford Pinto that we find in many textbooks for engineering ethics), employees will find themselves in an ethical dilemma: do they consent with the unsafe design knowing the risks for the users or do they resist, maybe even up to the level of whistle-blower?

In the second place, tensions can occur between norms in different interacting practices. This can also be between the same or between different types of norms. An example of a clash between the directional norms in two practices occurs when a government and a branch of industry have to find an agreement concerning the feasibility of certain environmental regulations. A government may reason from a point of view in which environmental protection is the highest value (if that government is much influenced by "green" parties), while the business companies may reason from profit-making as their highest

value. This, too, may cause ethical dilemmas for people in the government and in the companies. They may also occur between directional norms in one practice and constitutive norms in another. An example of that is the mismatch between a government preference to stimulate environmental protection and the absence of a department in a business corporation that should be concerned with that and could serve as a discussion partner. This is another example of a situation that may bring about ethical dilemmas for people in both practices.

TWO CASE STUDIES

First: Networked Military Operations

This case study (part of the PhD thesis by Christine van Burken) is meant to illustrate how tensions between different practices can give rise to ethical dilemmas. The case study concerns a networked military operation in Afghanistan (details can be found in Burken and De Vries, 2012). Here technology played an important role in causing the tensions between the practices. The story runs as follows: in September 2009, a pilot surveying in Afghanistan spotted an unidentifiable group of people on the ground. There were reasons for suspicion, as there was a real possibility that these were Taliban hijacking fuel trucks, which would be a threat to a German military camp nearby. A German colonel due to the information network was able to watch the pilot's screen from the tactical operations center. The American pilot was in doubt if bombing was the best option, given the possibility that these were not Taliban, but civilians. The German officer, however, watching the screen, ordered bombing and what appeared to be a group of innocent civilians indeed was killed in the event. The incident caused a great upheaval in the newspapers. Of course, the easy way was to blame the German colonel or the American pilot. Both were in an ethical dilemma: bombing with the risk of killing civilians instead of Taliban or not bombing with a risk for the nearby German military camp? An analysis using the normative practice concept, however, shows that the situation is too complicated for simply blaming officer or pilot (or both). In particular, the role of the technology needs to be examined here. It is due to the fact that this event happened in the context of a networked military operation. Due to the network, the officer could watch directly what the pilot was seeing. Without the network, this would not have been possible and the officer would have felt more distance to the pilot and his position directly above the ground. The fact that the officer had the opportunity to give his own interpretation to what was on the screen triggered him to interfere with the pilot's responsibility. The pilots were instructed only to bomb when they "felt good" about it, in the sense that they really felt the risk of bombing innocent people was as good as absent. The term "good" is used in a very intuitive way and is not defined in any specific sense. As the pilot did not have this feeling, he had asked permission to fly lower and investigate what exactly was going on down at the ground. The German officer, however, was involved so closely due to the network connection that he overruled these doubts. In terms of the normative practice concept, this is what happened. For the "officer practice" (that is, the practice of the German military staff, of which the German colonel was a participant), a directional norm was to ensure the safety of the German soldiers (in general, and including those in the nearby camp). In the "pilot practice", a directional norm was a concern for the people below him, whoever they were. The tasks and responsibilities (structural norms) were defined to fit with these respective structural rules. In his decision, the German officer in fact forced his directional norm into the pilot's practice. This created a conflict and thus an ethical dilemma for the pilot: disobey an officer or possibly kill innocent people. In order to follow the new directional norm, the pilot overruled his own structural rule,

namely to listen to his uncomfortable feeling about the bombing. Thus, two practices that normally would have been independent in that situation became entangled by the technology and this created tensions between the practices of the officer, respectively the pilot.

Second: Synthetic Biology

Synthetic biology is an emerging discipline that aims at manipulating life at the most basic level. Part of the domain manipulates existing life, and another part aims at creating living matter from non-living. The latter, of course, is ethically the most challenging, but both sub-domains are theoretically of interest in the light of our normative practices approach. As in the previous case, what makes it interesting (and ethically challenging) is the fact that two practices get mixed up, unless appropriate redefinitions of norms are realized. In this case, we are dealing with the normative practice of natural science (biology in particular) and the normative practice of engineering (bioengineering in particular). The two practices differ fundamentally in their qualitative norms. For scientists, the qualitative norms are related to truth-finding through investigation. The norms are concerned with defining what can count as new scientific knowledge and what not. For engineers, the qualitative norms are related to bringing forth new products and processes. The qualitative norms are related to what counts as a successful and working product. That these norms differ fundamentally can be seen from a few examples. The norms for scientific knowledge demand that knowledge to be context independent. Natural laws work independently of time and place. For engineers, however, the norms contain context dependency. What functions in one place or time may not function in another. What happens in the domain of synthetic biology is that natural scientists move towards the practice of engineering, as their aim no longer is studying life as it is, but to manipulate life so that a modified or new form of life is created (Carlson, 2010). That means the qualifying norms change. Or, in the terminology developed by Dooyeweerd, there is a shift from an analytically qualified practice to a formatively qualified practice. The norms, however, in the normative practice of natural sciences fitted with the other types of norms for that same practice (foundational, conditioning, and regulative or directional norms). Some of these norms are ethical, and in the case of living beings as objects, these norms are concerned with the dignity and protect-worthiness of life, as compared to non-living matter. The way we treat a machine may not be the same as the way we treat a living being (Schank, 2012). That certainly holds for humans and animals, but some ethicists will argue that it holds as well for plants or even to the lowest-level organisms.

In an international workshop, held in the Lorentz Centre in Leyden, the Netherlands, November 4 through 8, 2013 (www.lorentzcenter.nl/lc/web/2013/606/info.php3?wsid=606), an international group of synthetic biologists and philosophers discussed the interesting phenomenon of metaphors being used in synthetic biology. These are – surprisingly – mostly mechanical in nature (Bensaude-Vincent, 2009). Synthetic biologists talk about the cell as a "living machine". Making cells is compared to building with LEGO® bricks. The empty cell that is to be filled is called a "chassis". Although one should be careful not to derive too much from the use of these metaphors, it is striking that they are all mechanical in nature. During the workshop, this was identified as a typical engineering language being used by biologists. Several of the synthetic biologists expressed the feeling that they were now dealing with an entirely different type of work than when studying only life as it is. Developing knowledge remained part of the work (as in engineering also, by the way), but now the final aim was creating a new or modified form of life. This raised new ethical issues for them, as the norms in their natural science practice did not necessarily fit with the new

qualifying norms that are related to this new aim. In particular the issue around what morally can and what cannot be done with life was one that they had to reconsider seriously given this shift from only studying to manipulating life. Clearly, two different sets of norms, related to two different normative practices, had to be re-defined in order to get a new coherent set of regulative (directional) and constitutive (structural) norms, that was ethically satisfying. The debate about this will, no doubt, continue for the coming years. During the workshop it was suggested also to look for metaphors that fit better with the nature of the object of manipulation, for instance talk about the cell as a community (of parts) rather than a machine. Such a shift in metaphors may evoke different connotations with different ethical norms that do more justice to the fact that it is life that is manipulated.

FUTURE RESEARCH DIRECTIONS

The normative practice approach until now has only been applied to the medical (care) practice and the practice of military operations. In these domains, it proved to be valuable in developing accounts for what went wrong in some ethically problematic situations, such as the one mentioned in the first case in this article. There are still many other practices for which this approach can be a useful analytical tool for studying ethical issues. In the normative practice of education, for instance, one can see a shift in qualifying norms related to developing knowledge, skills, and attitudes towards norms that are related to making money. Universities get more and more involved in patenting and acquiring external funding from industries. It sometimes seems that the focus is more on this economic aspect than on the formative aspect of universities, in Dooyeweerd's terminology. That may invoke tensions between these new qualifying norms and the other norms that still belong to the normative practice of education. Another interesting domain for applying the normative practice approach is that of governments. Their qualifying norms are mostly seen as related to providing and maintaining public justice (in Dooyeweerdian terms: that are juridically qualified), but also for that practice one can see cases of shifts towards economical qualifying norms. That, too, can cause all sorts of new tensions between the various types of old and new norms.

CONCLUSION

The case studies have shown that the concept of normative practices is a useful analytical tool for examining complex ethical situations such as the ones that typically occur in engineering. The normative practice approach gives a perspective that allows to combine different ethical stances (virtues, duties, consequences) without losing coherence. This is because the norms can be related to motives of actors, as well as to actions themselves (what actions are allowed and what actions are forbidden) and to consequences of actions. The concept also suggests that all practices have an ethical dimension and that engineering therefore is never neutral. Ethics can be in all types of norms, not only in the regulative (directional) rules. The normative practice approach therefore almost by necessity leads to a rich ethical consideration as different types of norms have to be included in the analysis of the situation. This is particularly important in engineering, where often a reductionist approach is taken for pragmatic reasons. One could think, for instance, in the often over-estimated role of risk calculations in which everything is reduced to numbers. Such a reduction does no justice to the complexity of technological developments in relation to human, social, and cultural developments (de Vries, 2005). The normative practice approach forces the ethicist to consider a variety of norms, not just numerical norms. In particular for ethically sensitive domains such as the two mentioned in the case studies of this chapter (the

military practice and the synthetic biology practice), such a rich perspective is highly desirable. Also for less sensitive domains, this approach can prevent a simplistic search for pragmatic solutions. Engineering, after all, is too rich a domain for such pragmatics.

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KEY TERMS AND DEFINITIONS

Conditioning Norms: Norms related to the institutional, social (societal), economical and legal conditions that have helped to form the social practice.

Direction (of a Social Practice): The religious, spiritual and/or existential dynamic that supports and influences the social practice as it is embodied in the ethos and implicit worldview of the profession.

Foundational Norms: Norms that are related to the historical development that has led to the incorporation of scientific insight and technical skill in the social practice.

Normative Practice: Norms are inherent to a social practice; they are not just abstract principles or metaphysical ideas. Norms belong to the practice itself in an intrinsic way, such that, when these norms are violated the identity of the practice itself is threatened. 2. These norms (values) show a certain order and qualify the practice in distinct ways, especially the relationships between the various actors in the field of the social practice (Glas 2012).

Qualifying Norms: Norms that refer to the primary function of the social practice.

Social Practice: Any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realised in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of that form of activity, with the result that human powers to achieve excellence, and human conceptions to the ends and goods involved, are systematically extended (MacIntyre 1985, 187).

Structure (of a Social Practice): The processes, events and interactions that establish (form, determine) the practice as the practice it is.

Chapter 3
Engineering Ethics in Technological Design

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ABSTRACT

Engineering's main goal is to do and invent. Today's engineering, as the motive force of technology, has reached pressing new ethical issues. The objective of this chapter is to explain the role of engineering ethics in technological design. This chapter concentrates on ethical issues that have a direct influence on the design of a product and the way it is used. In general, it focuses on ethical issues concerning safety and sustainability.

INTRODUCTION

In the past few decades, rapid changes have been made in engineering education, including a growing emphasis on ethics and social responsibility. Engineering is not only applying scientific laws and principles to technical problems. It is focused on improving the lot of society, and as such, it brings engineers into the mainstream of business and industry. Almost all entry-level engineers become involved, at least tangentially, with situations that call for some understanding of the law and situations that call for ethical judgments.

Engineering technology has a profound influence on society. New possibilities and new risks arise as a consequence of the employment of new technologies and products. Decisions made during design processes shape the possibilities and risks of products. These decisions are ethically relevant. Some decisions, for example, can have a large influence on the safety of people using the product. Although there is an extensive literature on design processes and on engineering ethics, specific attention to ethical issues in design processes is relatively new.

We will call a problem an ethical or moral problem if moral values are at stake. According to Nagel (1979), there are different sources of value, special allegiances, general rights, utility, and perfectionist ends of self-development and individual projects that cannot be reduced to each other or to more fundamental values (Gorp, 2005, p. 14). Values based on special allegiances are, according to Nagel, a result of a subject's relationships to others and consist of special obligations to other people or institutions. General rights are

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rights that everyone has as a human being. These rights constrain action; actions that violate these rights are morally not permitted. According to Nagel (1979), utility includes all aspects of benefit and harm to all people. Perfectionist ends of self-development refer to the intrinsic value of certain achievements. Nagel provides examples of the intrinsic value of scientific discovery or artistic creation. The fifth type of value derives from individual projects. Nagel says that "this is value in addition to whatever reasons may have led to them in the first place" (pp.129–130). An example Nagel gives is that if you have set out to climb to the top of Mount Everest then this project gains importance. Ethical theories usually focus on one of the sources of value. Kantianism focuses on universal rights. Utilitarianism only accounts for utility. Virtue ethics concentrates on perfectionist end of self-development.

In this chapter, issues that are related to one of the sources of moral values identified by Nagel are called ethical issues and decisions concerning ethical issues are called "ethically relevant" decisions. For example, issues concerning safety are related to utility but also to universal rights, therefore safety is an ethical issue. The term "ethical issue" only indicates that the way engineers deal with an issue can be evaluated from a moral point of view.

The objective of this chapter is to explain engineering ethics and issues in technological design. Engineering ethics is the field of study that focuses on the ethical aspects of the actions and decisions of engineers, both individually and collectively. To take into account all ethical issues connected in one way or another to a design process would be impossible. It is not that difficult to point out the ethical relevance of what seems to be a very trivial choice, like which dress to wear during meetings of a design team. Lots of ethical issues might play a role in the design context, for example, chocolate made by children in countries like South Africa. This chapter will concentrate on ethical issues that have a direct influence on the design of a product and the way it is used. In general, it will focus on ethical issues concerning safety and sustainability. The reason for the focus on safety and sustainability is that these issues play a dominant role in many design processes. Given this conception of ethical issues it is clear that safety and sustainability may give rise to ethical issues. Decisions made about these issues are related to utility and general rights. Decisions regarding safety and sustainability are made in almost every design process, although the importance of these subjects may differ. In some cases, sustainability or safety will not be regarded or discussed by the engineers, but this does not mean that there are no choices made regarding sustainability or safety.

LEGAL AND ETHICAL ISSUES

Some of the ethical issues are also legal issues, for example safety issues.

The following are examples of where a design engineer might be concerned with ethical issues:

- Preparing a contract to secure the services of a product data management firm.
- Reviewing a contract to determine whether a contractor who built an automated production facility has satisfactorily fulfilled the terms of a contract.
- Deciding whether it is legal and ethical to reverse engineer a product.
- Managing a design project to avoid the possibility of a product liability suit.
- Protecting the intellectual property created as part of a new product development activity.
- Deciding whether to take a job with a direct competitor that is bidding on a contract in the area where you are now working.

The law is a formalized code of conduct describing what laws reflect what society values.

As society, its attitude toward behavior changes, and the laws change as well. Also, the evolution of technology creates new ethical issues. Ethics is the study of human conduct. It is intimately related to the values of society. Thus, laws and ethics, although distinct, are not independent. Ethical conduct is the behavior desired by society that is separate from the minimum standards of the law. For example, making a defective product despite taking all due care may subject you to product liability law, but it is not generally considered unethical.

Engineering ethics is the field of study that focuses on the ethical aspects of the actions and decisions of engineers, both individually and collectively. Ethical issues are discussed in engineering ethics: professional codes of conduct, whistle-blowing, dealing with safety and risks, liability, conflicts of interests, multinational corporations, privacy etc. (see for example Harris et al., 1995; Davis, 1998; Bird, 1998). Much of literature on the teaching of engineering ethics to engineering students has been developed since the beginning of the 1980s (cf. Baum, 1980; Unger, 1982; Martin and Schinzinger, 1989; Harris et al., 1995; Birsch and Fielder, 1994). A salient feature of engineering ethics literature is that a lot of it has been developed based on studies of disasters like the Challenger disaster (Vaughan, 1996 and Davis, 1998). Another feature of engineering ethics is that, especially in the United States, there are a lot of proponents who regard engineering ethics as a kind of professional ethics (cf Schaub et al., 1983; Davis, 2001 and Harris, 2004). The idea is that the engineer as a professional has obligations not only to his or her employer but also to the general public, as for example doctors or lawyers also have obligations. Engineers should adhere to professional codes of conduct that state, for example, that engineers shall hold the safety and welfare of the public paramount. Based on descriptions of the Challenger disaster, Davis emphasizes that there is a difference between engineers and managers.

Engineers should adhere to their professional norms and hold safety paramount but managers as such do not do this (Davis, 1998). This tendency to regard engineering ethics as a kind of professional ethics has led to a focus on the individual engineer and his or her responsibilities in his or her job and profession in most (American) engineering ethics textbooks. This can also explain the focus on whistle blowing that can be found in some of the engineering ethics literature. The individual engineer should in certain cases take his or her moral and professional responsibilities seriously and blow the whistle.

ETHICAL AND LEGAL DOMAINS

Ethics consists of principles of conduct that govern the behavior of an individual or a profession. It provides the framework for the rules of behavior that are moral, fair, and proper for a true professional. Ethical conduct is behavior desired by society and is above and beyond the minimum standards of the law.

The connection between legal and ethical action is illustrated by the following figure. In this model the solid vertical line presents a clear distinction between what is legal and illegal, as set forth by statute and case law. The location of the dashed horizontal line between ethical and unethical behavior is much less well defined. The actions considered ethical depend on values, some of which are important to society, some to the profession, some to the employer, and some to the individual. The task of the ethical professional is to balance these value responsibilities. These values are clarified for the professional and business by various codes of ethics.

Quadrant 1, legal and ethical behavior, is where an engineer should strive to operate at all times. Most design and manufacturing activities fall within this quadrant. Indeed, a good case can be made that quality is dependent on ethical behavior. “Doing what is right in the first place and

Table 1.

Quadrant 1	Quadrant 4
Legal/Ethical	*Illegal/Ethical*

doing what is best for all involved, when done at every level of the organization and in every work process, has proven to be the most efficient way of conducting a business."

Quadrant 2, legal and unethical, is the concern of the rest of this chapter. The goal is to explain how to identify unethical behavior and to learn what to do about it when it occurs. There is a feeling that unethical behavior in the workplace is increasing because of increasing workplace pressures and changing societal standards. Most corporations have adopted codes of ethics. Many have established an ethics office and are offering ethics training to their personnel. It is interesting that the prevailing view about ethics instruction has changed substantially. Throughout most of the 20th century, the common view about ethics was that you either learned ethics in the home when you were growing up, or it was too late. This is changing today to a view that ethics is a teachable subject that can be learned by just about everyone.

Quadrant 3, illegal and unethical, is the sector where "go-to-jail" cards are distributed. In general, most illegal acts also are unethical.

Quadrant 4, illegal and ethical, is a relatively rare event. An example could be an engineer who had signed a secrecy agreement with an employer, but then found that the employer had been engaged in producing a product that was very hazardous to the general public. Unable to get attention focused on the problem within the company, the engineer goes to the press to warn the public. The engineer has breached a contract, but in what is believed to be a highly ethical cause. Such a person would be called a whistle blower.

A small child threw an aerosol can into a blazing fireplace. The can exploded, injuring the child, and the child's father sued the manufacturer of the cleaner in the spray can. The manufacturer defended itself by stating that the can contained a label warning the user not to incinerate. The child's father argued that the manufacturer should have anticipated that some cans would accidentally be incinerated and that some sort of fail-safe design should have been provided to prevent explosion.

The manufacturer of the spray can won the case by arguing that the presence of a warning label against incineration should excuse liability for the injury. This is a situation where the present state of technology does not provide for a safe means of preventing an explosion upon rapid rise in temperature. The manufacturer should not be held liable so long as the users of the product have been clearly warned of potential dangers. In fact, the parents of the child were really negligent for allowing their child to play with an aerosol can near an open fire.

CODES OF ETHICS

Morality refers to those standards of conduct that apply to all individuals within society rather than only to members of a special group. These are the standards that every rational person wants every other person to follow and include standards such as the following:

- *Respect* the rights of others.
- Show *fairness* in your dealings with others.
- Be *honest* in all actions.
- *Keep promises* and contracts.
- Consider the *welfare* of others.
- Show *compassion* to others.

Bernard Gert has formulated a set of ten moral rules that are listed as follows:

G1: Don't Kill
G2: Don't cause Pain
G3: Don't Disable
G4: Don't deprive of Freedom
G5: Don't deprive of Pleasure
G6: Don't Deceive
G7: Keep your Promise
G8: Don't Cheat
G9: Obey the Law
G10: Do your Duty

Note that each of these standards of conduct is based on the italicized values. By professional ethics, we mean those standards of conduct that every member of a profession expects every other member to follow. These ethical standards apply to members of that group simply because they are members of that professional group.

Like morality, standards of ethical conduct are value based. Some values that are pertinent to professional ethics include:

1. **Honesty and Truth**
2. **Honor:** Showing respect, integrity, and reputation for achievement.
3. **Knowledge:** Gained through education and experience.
4. **Efficiency:** Producing effectively with minimum of unnecessary effort.
5. **Diligence:** Persistent effort.
6. **Loyalty:** Allegiance to employer's goals.
7. **Confidentiality:** Dependable in safeguarding information.
8. **Protecting Public Safety and Health**

Note that some of these values are directed toward the employer (e.g., diligence), some toward the customer and employer (e.g., confidentiality), some toward the profession (e.g., honor), and some toward society (e.g., public health and safety). These values reflect the professional's value obligations.

CODE OF ETHICS OF ENGINEERS

The Fundamental Principles that Engineers uphold and advance the integrity, honor, and dignity of the engineering profession by:

1. Using their knowledge and skill for the enhancement of human welfare.
2. Being honest and impartial, and serving with fidelity their clients (including their employers) and the public.
3. Striving to increase the competence and prestige of the engineering profession.

The Fundamental Canons are listed as follows:

1. Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in the areas of their competence; they shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.
4. Engineers shall act in professional matters for each employer or clients as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest.
5. Engineers shall respect the proprietary information and intellectual property rights of others, including charitable organizations and professional societies in the engineering field.
6. Engineers shall associate only with reputable persons or organizations.

7. Engineers shall issue public statements only in an objective and truthful manner and shall avoid any conduct that brings discredit upon the profession.
8. Engineers shall consider environmental impact and sustainable development in the performance of their professional duties.
9. Engineers shall not seek ethical sanction against another engineer unless there is good reason to do so under the relevant codes, policies, and procedures governing that engineer's ethical conduct.
10. Engineers who are members of the Society shall endeavor to abide by the Constitution, By-Laws and policies of the Society, and they shall disclose knowledge of any matter involving another member's alleged violation of this code of Ethics or the Society's Conflicts of interest policy in a prompt, complete, and truthful manner to the chair of the Committee and Ethical Standards and Review.

ETHICAL ISSUES IN ENGINEERING AND TECHNOLOGICAL DESIGN

Lloyd and Busby use empirical data to describe how engineers deal with ethical issues in design (Lloyd & Busby, 2003). They use three main ethical theories to categorize reasoning and argumentation during the design process. They refer to the three ethical theories as "consequentialism," "deontology," and "virtue ethics." They looked at all reasoning, not just at reasoning about issues that are clearly ethical like safety (Lloyd & Busby, 2003, p.514). For example, they relate reasoning about making a better product to consequentialist reasoning. They conclude that, contrary to their expectations, consequentialist reasoning is not prevalent in engineering design.

Engineers also use deontological reasoning and engineers identify what Lloyd and Busby call virtues of engineers like collectivity, consistency, and emphasizing evidence. Lloyd and Busby have considered normal day-to-day situations in which design decisions are made. According to Lloyd and Busby small design decisions that each seem to be ethically neutral can add up to ethically relevant consequences:

In contrast to Lloyd and Busby, who studied the (ethical) reasoning that engineers use in design processes, Van de Poel distinguished five actions during the design process that may be ethically relevant.

1. The formulation of goals, design criteria, and requirements and their operationalization.
2. The choice of alternatives to be investigated during a design process and the selection among those alternatives at a later stage in the process.
3. The assessment of trade-offs between design criteria and decisions about the acceptability of particular trade-offs.
4. The assessment of risks and secondary effects and decisions about the acceptability of these.
5. The assessment of scripts and political and social visions, which are (implicitly) inherent in a design and decisions about the desirability of these scripts.

Van de Poel's approach would imply that, for example, the formulation of requirements is an action that can be expected to be done during design processes. Formulating requirements can be ethically relevant, for example, if safety requirements are formulated. These requirements need to be operationalized and this operationalization is also ethically relevant. Different alternatives that score differently with respect to different requirements and different operationalizations of requirements may have to be assessed. Trade-offs between different requirements may have to be made. In accordance with Van de Poel's approach, these actions can all be ethically relevant if related

to moral values, and therefore these are included in this chapter.

Given our conception of ethical issues, it is clear that safety and sustainability may give rise to ethical issues. Decisions made about these issues are related to utility and general rights. Decisions regarding safety and sustainability are made in almost every design process, although the importance of these subjects may differ. In some cases, sustainability or safety will not be regarded or discussed by the engineers, but this does not mean that there are no choices made regarding sustainability or safety.

For example, when designing a printer/copier, a choice needs to be made as to whether the printer/copier will be able to print two sided or one. Once a choice is made for two-sided printing and copying, an additional choice needs to be made about the default properties. If two-sided printing is the default option, users have to make an explicit choice to print one sided. Usually the prints and copies coming of the machine will be printed two sided. Only in exceptional cases, where the two-sided copies and prints option is switched off by the user, will papers be printed one sided. This default option may save a lot of paper compared with a printer/copier that can only print one side. The environmental effects of saving paper are not that big if a single printer/copier is regarded but when the total number of printers/copiers in use is considered the amount of paper saved by printing two-sided copies and prints could be enormous. As paper is produced from wood, a reduction in paper use will also reduce the amount of wood used. The production of paper, the transportation of wood, and the transportation of paper all require energy. The amount of energy used may also be reduced and the total reduction in the resources used will be significant on a global scale. This example shows that decisions made during a design phase of a product, and that seem trivial during that phase, can have large environmental effects.

Let us consider another example. A person may decide not to drive too fast as this is usually dangerous and not environment friendly. The government of a country might decide to regulate the speed of cars by imposing speed limits. If there are speed limits imposed drivers can still drive as fast as they wish, but they will run the risk of being fined when exceeding the speed limits. Car engineers might decide to design a car in which it is impossible to exceed the speed limits. For example cars in Karnataka are equipped with a speed regulator that makes it impossible for the driver to drive faster than 60 km/h. This example illustrates the influence engineers may have; they can promote or prevent speeding. Independently of what regulation requires or what speed limits are legally enforced, engineers can design cars with lower top speeds. Cars with top speeds of 300 km/h make speeding possible and might perhaps invite drivers to test the top speed whereas installing a speed regulator or designing a car with a less powerful engine would make such speeding impossible. Designing cars with lower top speeds would also save a lot of fuel as the fuel consumption is higher at higher speeds. Lower fuel consumption also decreases CO_2 production. Smaller speed differences, for example between trucks and cars may decrease the number of accidents occurring on roads and thereby the number of people injured and killed on roads. So by choosing to design a car with lower top speeds, be it by actively limiting the top speed of the car or designing a less powerful engine, engineers can reduce fuel consumption, CO_2 production, and the amount and severity of accidents on highways.

Design Process

Design is usually not carried out by a single individual; typically, it is a collective effort. Some people will design a specific part, others will integrate partial designs into an overall design, and still others will mainly be involved in project management. The way the design task is divided up between different teams/groups and individuals is ethically relevant, because it will in most

cases have consequences for the products that are eventually designed. Moreover, it will affect the responsibility of the people involved. With respect to the latter, a distinction could be made between two types of responsibility: active and passive responsibility. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation.

Cross (2000) stated that design could be seen as a process in which products or tools are created to suit human purposes (p. 3). The starting point of a design process is usually some stated or perceived customer's needs. A material structure that meets these functional requirements is designed. The design process is usually constrained by economic and time restrictions. A design should be finished by a certain date and the costs of the whole design process should not exceed a certain amount of money.

Cross presents a model of the design process that consists of three phases: generation, evaluation, and communication. A concept is generated in the first phase of the design process. A designer needs to understand the design problem and to find possible solutions for it; this usually happens simultaneously. Possible solutions help the designer to get a better understanding of the design problem. The concept is evaluated in the second phase. During the evaluation, a decision is made as to whether the possible solution meets the requirements. The concept is adapted in an iterative process. Often, more than one iterative step is necessary because adaptation of a part of the design can lead to problems in other parts of the design. The design is communicated to the people who are responsible for production in the third phase. Drawings, computer drawings, and descriptions of the design are used in this communication.

French divides the design process into four activities:

- Analysis of the problem
- Conceptual design
- Embodiment of schemes
- Detailing

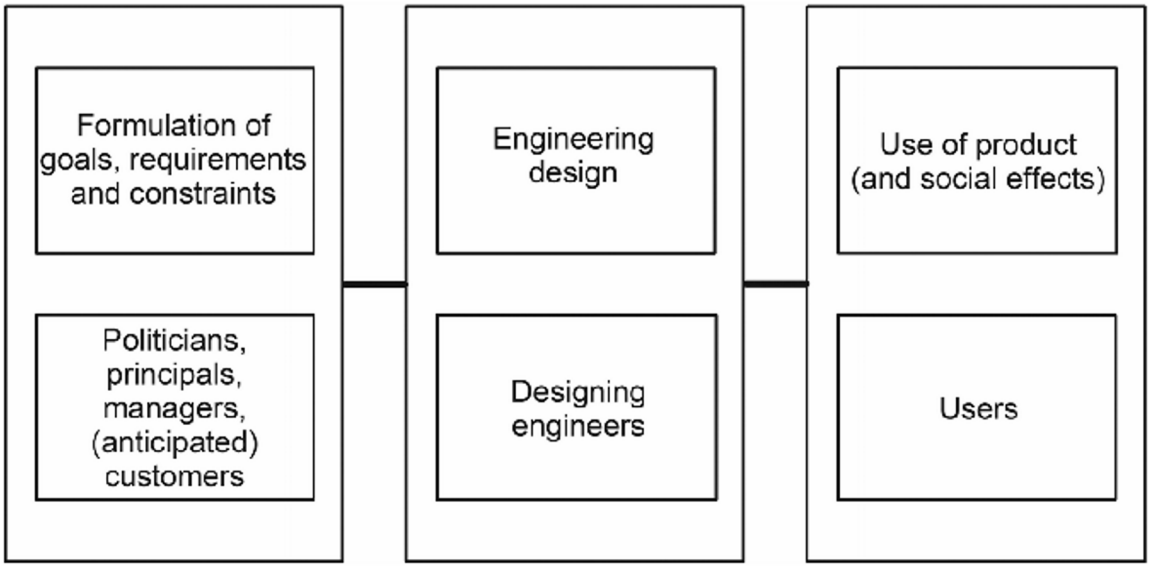
An analysis of the design problem should lead to a clear statement of the problem. The requirements and constraints are formulated in this phase. The designer searches for different possible solutions and makes schemes of them in the conceptual design phase. In the next phase, embodiment of schemes, a choice is made between the schemes. The scheme is further detailed in the detailing phase.

According to Florman, the formulation of requirements and goals is ethically relevant, but this should not be done by engineers. Managers, politicians, customers, etc. should formulate the requirements. In this line of thinking, the task of engineers is to discover what is technologically the best solution given certain requirements. Discovering the best solution given the requirements is seen as ethically neutral. Ethical questions may arise when technologies are used for certain purposes and produce certain (social) effects. According to Florman, these ethical questions concerning use are also outside the scope of the engineers and should be solved by the user. In this model, the sole responsibility of engineers is to carry out a task formulated by others.

According to Simon the main characteristics of an ill-structured problem are that the solution space is not well defined and there is no criterion to test different solutions and decide which is best. Cross gives the following characteristics of ill structured problems:

1. There is no definite formulation of the problem.
2. Any problem formulation may embody inconsistencies.
3. Formulations of the problem are solution-dependent.
4. Proposing solutions is a means to understanding the problem.

Figure 1. Division of labor with respect to engineering design if design problems were well-structured problems in which the requirements fully determine the solution



5. There is no definitive solution to the problem.

Some design methods require that engineers formulate the requirements and solutions separately and independently, but this is impossible if design problems are ill structured. In a redesign of an existing design it might be possible to formulate most of the requirements at the start of the design process but this is not a definition of the requirements independent of the solution. The solution space is, in these cases, limited because a redesign is made; certain features of the product will remain the same. Other design problems aiming at designing a completely new product are very ill structured and only some vague requirements can be formulated at the start of the design process. So, design problems can be more or less ill structured.

Design as Social Responsibility

In general, designs are made by a team of engineers. Designing is in these cases a social process. Choices are made in, and by, groups of people. During the design process, communication, negotiation, argumentation, mistrust between engineers, and power differences between engineers influence the design. This has consequences for design research, as the design process should be conceptualized as a social process. There is some research into actual design processes with design teams (Bucciarelli, 1994; Lloyd & Busby, 2001; Lloyd, 2000; Baird et al., 2000). Bucciarelli describes the design process as a social process in which negotiation is necessary.

Different engineers, with their different educational background and experiences, may conceive the design task differently. Take for example the cage construction and bodywork of a car. A mechanical engineer looks at stresses and strains within the cage construction and bodywork of a car. He or she tries to design the cage and bodywork in such a way that stresses and strains remain low during normal use and absorb energy during a crash. An aerodynamics engineer might look at the same bodywork and sees a body that needs to have a low frontal area and a low drag coefficient. Although both the mechanical and

the aerodynamics engineer look at the same parts they see something different and think of different requirements the parts should meet. All these different views have to be 'brought in coherence' (Bucciarelli, 1994), just like all the parts have to fit and function together. This "bringing into coherence" is done as a process of communication and negotiation.

Other authors also recognize the importance of social processes during the design process and stress the importance of communication. Lloyd stresses the importance of storytelling within the design process (Lloyd, 2000). Engineers construct stories during the design process. These stories are used to come to a common understanding.

Design Hierarchy

Most modern products consist of several parts, subassemblies, and subsystems. In many cases these subsystems and parts are more or less independently designed. Depending on how the design process is organized, different teams and engineers work on different parts of the product. There is communication and cooperation between the teams or at least there should be. These design teams can be from the same or from different companies. The parts, subassemblies, and subsystems are ordered hierarchically. The complete product is designed at the highest levels of the design hierarchy; subsystems and parts are designed at lower levels. Vincenti (1990) divides the hierarchy of the design process of an airplane in the following levels.

1. **Project Definition:** translation of some usually ill-defined military or commercial requirement into a concrete technical problem for level 2.
2. **Overall Design:** layout of arrangement and proportions of the airplane to meet the project definition.
3. **Major-Component Design:** division of project into wing design, fuselage design, landing-gear design, electrical-system design, etc.
4. Subdivision of areas of component design from level 3 according to engineering discipline required (e.g., aerodynamic wing design, structural wing design, mechanical wing design).
5. Further division of categories in level 4 into highly specific problems e.g. aerodynamic wing design into problems of platform, airfoil section, and high-lift devices (p. 9).

There are similarities between Vincenti's ideas of design hierarchy and the design hierarchy defined by Disco et al. Disco et al. (1992) distinguish the following levels of hierarchy:

- Systems, like a plant, electricity, or cable networks.
- Functional artifacts, like cars, etc.
- Devices like pumps, motors, etc.
- Components, like materials, nuts, condensers, etc.

ETHICAL CONFLICTS

Ethical theory considers two extreme types of behavior. Altruism is a form of moral behavior in which individuals act for the sake of other people's interests. This is the viewpoint best summarized by the Golden Rule: Do unto others as you would have others do unto you. Egoism is a form of moral behavior in which individuals act for their own advantage. Ethical egoism is the view that individuals ought always to act to satisfy their own interests. Most day-to-day practice of engineering is done in the individual's self-interest and is not in conflict with the codes of ethics. However, the codes of ethics are meant to alert the practicing professional that he or she has altruistic obligations that must be properly balanced with self-interest.

If an engineer mishandles a situation, his or her career can be damaged even in cases where he or

she is trying to do the right thing. Therefore, it is important to know how to handle ethical conflicts and to have thought about conflict resolution before being confronted by a problem.

Procedure for Solving Ethical Conflicts

1. Internal appeal option
    a. Individual preparation
        i. Maintain a record of the event and details
        ii. Examine the company's internal appeals process
        iii. Be familiar with the state and federal laws that could protect you
        iv. Identify alternative courses of action
        v. Decide on the outcome that you want the appeal to accomplish
    b. Communicate with your immediate supervisor
        i. Initiate informal discussion
        ii. Make a formal written appeal
        iii. Indicate that you intend to begin the company's internal process of appeal
    c. Initiate appeal through the internal chain of command
        i. Maintain formal contacts as to where the appeal stands
        ii. Formally inform the company that you intend to pursue an external solution
2. External appeal option
    a. Individual actions
        i. Engage legal counsel
        ii. Contact your professional society
    b. Contact with your client (if applicable)
    c. Contact the media

Ethical decision-making is not easy. However, the chances for successfully resolving an ethical conflict can be greatly increased by following a systematic procedure. Except under the unusual circumstances of imminent danger to the public, it is important that all internal steps should be explored before seeking options outside of the organization. The process of seeking resolution to an ethical conflict within the organization is usually handled through an appeals process within management or by the complaint process through the office of the ombudsman or the ethics officer. The table gives a step-by-step procedure for resolving an ethical conflict, or any conflict for that matter, through an internal appeals process and external to your company.

The steps that the individual should take in preparation for disclosure of unethical behavior are straightforward. Once you have studied and documented the facts and formulated a plan for appeal, you should discuss the matter with your immediate supervisor.

Whistle Blowing

Whistle blowing is the act of reporting on unethical conduct within an organization to someone outside ordinary channels in an effort to discourage the organization from continuing the activity. In the usual case the charges are made by an employee or former employee who has been unable to obtain the attention of the organization's management about the problem. Sometimes whistle blowing is confined to within the organization, where the whistle blower's supervision is bypassed in an appeal to higher management. An important issue is to determine the conditions under which engineers are justified in blowing the whistle. DeGeorge suggests that it is morally permissible for engineers to engage in whistle blowing when the following conditions are met:

- The harm that will be done by the product to the public is considerable and serious.
- Concerns have been made known to their superiors, and getting no satisfaction from their immediate superiors, all channels

have been exhausted within the corporation, including the board of directors.
- The whistle blower must have documented evidence that would convince a reasonable, impartial observer that his or her view of the situation is correct and the company position is wrong.
- There must be strong evidence that releasing the information to the public would prevent the projected serious harm.

CASE STUDY

The design process for piping and pressure equipment for (petro) chemical installations is introduced in this chapter.

In the chemical industry the design problem is predominantly delineated in the earlier stages by the chemical company. From the moment an engineering company is contracted to produce a plant design there is communication and co-operation between the engineering company and the chemical company. At the engineering company the piping and equipment design process starts with the making of a flow chart. This chart is used to specify the amount and rates of the different liquid and/or gas flows, and will be based on information provided by the customer. After the chemical flows have been established, pipe diameters, vessel sizes, and other dimensions are calculated. When the necessary types of apparatus and pipelines are known, the positions of the various vessels in the plant and pipelines and the layout are decided. Things like access for inspection and cleaning are taken into account during this process. The stresses in the material are calculated, and decisions are made as to what specific pipe materials etc. to use. There is feedback between those making the calculations of stresses and those determining the positions of pipes and vessels in the plant. These processes are followed by filling out the details of the design and the bearing understructure. The "Manager of Engineering" of the engineering company estimated that about 75% of the design process time at this company was consumed by the process of detailing the design.

Responsibilities and Tasks

The organization of the engineering company was as follows. The company had a matrix organization; this meant that there was line organization in disciplines and horizontal organization in project teams. Every project team consisted of people who were also part of a line organization. A project manager would, at the start of a design process, consult line managers about the people he or she wanted in the project team. If the project was large, the project team members were relocated to work in the same space. There was a clear division of labor and function descriptions were clear.

- **Job Engineer:** The job engineer is usually an experienced engineer. He or she is responsible for the plant layout. The job engineer has to deal with constraints related to regulation and constraints related to economy. Environmental, safety, and nuisance regulations are important in the plant layout. For example, he or she has to take care that safety distances between tanks and stoves and between tanks containing certain chemicals and the outer fence of the company are taken into account. Apparatus that produces too much noise needs to be shielded to reduce noise levels inside and outside the installation.
- **Stress Engineer:** The stress engineer calculates the stresses in the pipes, the stresses in the connections between pipes and vessels, and the stresses the pipes exert on the supporting structures. These calculations are made once there is a plant layout. If the calculations show that stresses are too high, some changes in the plant layout may have to be made. The calculations are made according to codes.

- **Materials Engineer:** The materials engineer chooses which materials are used in an installation. Criteria used to choose materials are strength and chemical resistance.
- **Piping Designer:** The piping designer makes a three-dimensional computer model of the installation. The many elements of the computer model are preprogrammed.

The piping designer chooses among the existing elements to build the model. Once the three-dimensional model is ready, simulations of people walking through the installation or parts being taken apart are made. If the piping designer notices problems, he or she confers with the stress engineer, the job engineer and/or the materials engineer. At this stage of the design accessibility and the ergonomics of the installation are important subjects.

An important ethical issue in piping and equipment design is safety. The question "What is safe enough for piping and equipment in a chemical installation?" is in practice usually answered by referring to codes and regulations. The design team does not try to answer this question itself. In fact, the design team designs an installation that is safe enough according to existing codes and regulations. Although legislation, regulation, codes, and standards play a large part in the design of chemical installations, there are still some choices on safety that engineers have to make, for example substantial improvements in safety over existing practice that can be made at little or no increase in cost.

Many decisions regarding safety are already specified in codes, for example, safety factors, formulas, material properties, and maximum allowed stress or strains. The design team has no freedom in the calculations. However, the team has to decide what load scenarios to calculate.

CONCLUSION

This chapter focuses on an engineer's role in design. Engineering is a profession that is critical to the advancement of society. How engineers do their jobs determines what kind of world future generations will enjoy. Thus, engineering involves you in making ethical judgments. Most will be small, involving your relationship with your management and your fellow engineers, but others could be momentous, affecting the safety of a city.

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KEY TERMS AND DEFINITIONS

Altruism: Altruism is the principle that concerns for the welfare of others.

Challenger Disaster: The direct cause of the Challenger explosion was technical - faulty O-rings.

Deontological Reasoning: Deontological reasoning states about certain duties. It observes that whether the present instance is real or hypothetical, which falls under that duty and proceeds to derive the obligation to carry out that duty.

Engineering Ethics: A set of rules and guidelines that engineers adhere as a moral obligation to their profession and to the society. It is also defined as the study of related questions about moral conduct, character, ideals, and relationships of people and organizations involved in technological development

Ethical Conflict: Ethical conflicts generally arise when people are confronted with a collision between general belief systems about morality or justice and their own personal situations.

Ethical Egoism: Ethical egoism is the moral agents ought to do what is in their own self-interest.

Functional Artifacts: Technological gadgets are usually identified as technological artifacts, which are also called functional artifacts.

Chapter 4
Engineering Ethics
Global Climate Change, and the Precautionary Principle

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ABSTRACT

Besides respecting relevant codes of professional ethics, engineers should heed the principles of common morality and international law, including the Precautionary Principle, which requires action to prevent serious or irreversible harm in advance of scientific consensus, when reasons exist to credit such harm. In this chapter, this principle is shown to be applicable to many kinds of technology. An objection that seeks to assimilate it to policies of Maximin is shown to miscarry. The principle is further interpreted as concerning avoidable reductions of future quality of life. The phenomenon of anthropogenic climate change is then shown to involve challenges for engineers. In addition to principles of justice and of benevolence, the Precautionary Principle is found to be relevant once again to such decision making. Finally, considerations of humanity's limited carbon budget are adduced to indicate, in the light of these principles, the inappropriateness of extreme forms of energy extraction.

ABSTRACT: AN EXPLICATION

As well as respecting relevant codes of professional ethics, engineers engaged in decision-making should heed the principles of common morality and of international law. One relevant principle recognized in international law (and agreed at the Rio Conference on Environment and Development of 1992) is the Precautionary Principle, which requires action to prevent serious or irreversible environmental harm in advance of scientific consensus, when reasons exist to credit the prospect of such harm.

The Precautionary Principle is introduced and shown to be applicable to several kinds of technology, such as the production of biofuels, and of engineering, such as tar sands extraction. This Principle has been accused of involving policies of Maximin. However, the crucial difference between the two stances or principles is clarified and explained. Policies of Maximin could involve abandoning scientific progress, together with all forms of adventurousness, whereas the

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Precautionary Principle does not involve any of this, and can even mandate activism in cases where inaction is likely to generate serious or irreversible harms. But some applications of technology also risk generating such harms—or their equivalent, a reduction of future quality of life. Thus, biotechnologists need to be trained to understand the Precautionary Principle and its implications, so as to distinguish benign innovations from innovations which it would be unethical to introduce on precautionary grounds.

The phenomenon of global climate change, and the associated exposure of millions of people to dangers they have not caused, raises further ethical issues for decision-making in engineering. The risks include the inundation of coasts and small islands, and increasingly frequent and intense extreme weather events, as well as the spread of diseases like malaria and dengue fever, and the dispossession of millions of environmental refugees. Such central principles of common morality as benevolence and justice require policies of mitigation, as well as of adaptation to climate change, policies which involve the participation of engineering decision-makers. These policies are also required by the precautionary principle, as there are clear reasons to credit serious and irreversible harm (or equivalent) from climate change, and hence action is required despite the absence of complete scientific consensus.

In view of the dangers attendant on a temperature increase of over two degrees (Celsius) above pre-industrial levels, and the need to limit carbon (or equivalent) emissions to 01 trillion tonnes to attain a 50% chance of avoiding such dangers, certain further engineering practices should be avoided, such as methods of extreme extraction of hydrocarbons, in view of the importance of not putting to use all the known hydrocarbon reserves. In these circumstances, some practices (such as fracking and drilling beneath the Arctic Ocean) that are apparently morally neutral prove to be unjustifiable on precautionary and other ethical grounds.

INTRODUCTION

The ethics of engineering includes abiding by professional codes of conduct and of professional proficiency. Thus, the bridges an engineer builds must not fall down, and the tunnels she constructs must not become flooded or undergo the collapse of walls or roofs; and in general obligations to clients should be satisfied. But these responsibilities are only a part of engineering ethics. Engineers should also comply with common morality, for example, treating everyone justly and without exploitation, including those aspects of common morality that are enshrined in international law.

This chapter focuses in part on one such aspect, the Precautionary Principle, which (as we shall shortly see) was unanimously endorsed by the Rio Conference on Environment and Development of 1992, also known as the Earth Summit, and thus has the status of international law, and carries the recognition and support of just under 200 countries which participated in that Summit. This Principle is elucidated, an objection is considered and rejected, and the scope of the Principle is further elicited; its importance turns out to be such that all students of engineering should be introduced to it and its implications. Later the chapter moves on to ethical principles and decision-making related to global climate change, which turn out to have a considerable bearing on decisions to which engineers are party, and on the scope of projects that they should embark upon. But let us focus to begin with on the Precautionary Principle.

THE PRECAUTIONARY PRINCIPLE

In a nutshell, the Precautionary Principle declares that where there is reason to regard a substance or process as seriously or irreversibly damaging, for example in an environmental context, preventive action or regulation should be undertaken despite the absence of scientific certainty or consensus. Although this is not a basic ethical principle, it

gives valuable ethical guidance, and valuably supplements other ethical principles when decisions have to be taken against a background of partial uncertainty. But such is increasingly the background against which decisions have to be made, not least the decisions of engineers, and accordingly the kind of guidance that the Precautionary Principle supplies is increasingly needed.

This principle can take stronger and weaker forms, and at the same time be expressed with greater precision and accuracy than the description of the Principle in a nutshell presented earlier. An example of a stronger form of the Principle is the London Declaration on the Protection of the North Sea (1987). This Declaration authorizes the regulation of substances "when there is reason to assume that certain damage or harmful effects on the living resources of the sea are likely to be caused by such substances, even where there is no scientific evidence to prove a causal link between emissions and effects."[1] (Here the word "certain" just means "specific"; the Declaration was not saying that the damage or harmful effects were incontrovertibly foreseeable, or in that sense "certain.") Clearly, this principle could be adjusted so as to concern processes or projects rather than substances. If such a strong principle were widely adopted across different jurisdictions, then a very great deal of regulation of potentially dangerous substances and processes would be authorized.

By contrast, an example of a weaker form of the Principle is found in the Rio Declaration (1992), which affirms that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[2] This is weaker because interventions are restricted to ones that are cost-effective, and (more importantly) because other reasons than the lack of scientific certainty might be found against regulatory action. Yet even in this weak form, the Principle has great importance, because it forbids inaction simply on the basis of scientific disagreement, and because it was adopted into international law by all the countries represented at Rio, including the countries of most readers of this chapter, and crucially including those to which the largest engineering companies are subject.

By way of illustration, it is worth investigating whether the Principle applies to the form of engineering known as "biotechnology." Is there sometimes reason to believe that serious or irreversible damage could result from its applications? With regard to agricultural applications of biotechnology, the answer is probably "yes," for the introduction of palm-olive plantations for biofuel production in countries such as Malaysia has often led to increases of malaria among workers and local people, as well as endangering the species of the forests replaced by the plantations. There again, the introduction of genetically modified varieties of food species into the environment sometimes brings dangers to native species of cross-breeding and thus of the extinction of the original wild species, and of the new varieties becoming "super-weeds," out-competing native species, even without cross-breeding. So there is sometimes reason to believe that such introductions do serious damage, irreversible damage, or sometimes both; and when this is the case, it triggers the Precautionary Principle, even if there is no scientific consensus about such damage being caused.

These examples may serve to indicate that the Precautionary Principle is often relevant to a wide range of kinds of engineering. Projects of civil engineering such as the construction of bridges and of dams (to introduce examples from another field of engineering) often, although not always, turn out to involve prospects of serious and/or irreversible damage. Similar remarks apply to the manufacture of automobiles, to some forms of mineral extraction and to the construction of power stations, and to the proposed form of engineering that would modify the planetary climate, geo-engineering, to say nothing of the application of technology to military uses and

weaponry. Clearly the potential applications of the Precautionary Principle are extensive, and thus all the more important for consideration when decisions are being made.

AN OBJECTION CONSIDERED

The very fact that the implications of the Precautionary Principle are both great and extensive in their scope has led some scientists and philosophers to question its acceptability, despite its widespread acceptance and recognition in international law. The Precautionary Principle, it is said by the critics, amounts to the Principle of Maximin, according to which agents should select the course of action among their options (inaction included) of which the worst outcome would be the least bad. So understood, this Principle bids us review the conceivable outcomes of our various options, and avoid all but the least risky of them (which might often be the option of inaction or of doing nothing). It would therefore stultify initiative, adventurousness, and enterprise, discourage experimentation (and, granted that experimentation is pivotal for scientific advances, block the advance of science itself), and in addition make being perennially cautious a constant moral requirement.

It may however be replied that the Precautionary Principle simply does not advocate any such Maximin principle or policy. For it does not focus on preventing the worst outcome that could conceivably happen, but rather on preventing outcomes that there is reason to consider as significant threats or dangers, ones that, as well as being of a serious or irreversible nature, are also significantly possible. While extreme risk-aversion counsels not venturing out-of-doors in case of possibly being struck by lightning, by contrast the Precautionary Principle actually sometimes advocates not inaction, in cases where inaction would have serious or irreversible consequences, but bold action to prevent, for example, tidal surges and life-threatening forest fires, phenomena which most people recognize (on the strength of recent trends) as likely to increase both in magnitude and frequency because of anthropogenic climate change. Far from eradicating initiative, the Precautionary Principle can empower fearless positive campaigning (like that of Greenpeace) for the sake of a sustainable future, rather than one that is irreversibly damaged (whether this would result from current action or inaction), as well as assisting in discerning which policies can rationally be risked, and which cannot. It can recognize that it is often inaction that would generate serious or irreversible harm, as when coastal erosion is left unchecked or flooding is treated as beyond prevention, and that bold initiatives and reflective activism (whether in campaigning or in social policies) are the ways to avoid a drift to disaster. The Precautionary Principle, unlike the Principle of Maximin, does not engender a paralysis of inaction, but the adoption of well-planned preventive strategies (Robin, 2015).

Accordingly the Precautionary Principle should not be rejected on the grounds conveyed in this objection, nor be misrepresented as advocacy of extreme caution. Indeed this Principle should be applied to anti-technology campaigns as well as to technological innovations, because the former as well as the latter could put people at risk of unnecessary harm. Thus if a genetically modified strain of wheat or rice could rescue millions of people from starvation, without serious countervailing side effects, then the Precautionary Principle tells us that inaction is what we should avoid, rather than the smaller risks attending the introduction of this strain. Yet it applies equally to technological changes as well as to misdirected campaigns of protest; and we should not be distracted from adhering to it through caricatures such as its misrepresentation as a policy of institutionalized caution or extreme risk-aversion.

My conclusion is that the objection that identifies the Precautionary Principle with the

Principle of Maximin is misguided, and should be disregarded.

HARM AND/OR REDUCTION OF QUALITY OF LIFE

The Precautionary Principle enjoins action to prevent serious and/or irreversible damage or harm befalling human or nonhuman individuals. There is however a problem about applying it to those future people who have not yet been conceived, as present people cannot damage or harm them as individuals. (Although damage and harm are not identical, the difference between them can be ignored as irrelevant for present purposes.)

Individuals can only be damaged or harmed if they could have been undamaged or unharmed, and can only be damaged or harmed by present agents if such unharmed (etc.) individuals could be made worse off through the action or inaction of these agents. But many unconceived future individuals would exist only in one future scenario or world, and thus could not be made worse off by present agents, as this would only be possible if they were to exist in more than one future world (as, *ex hypothesi*, they do not). Present agents can make differences in their regard, for example through the behavior of different couples in meeting and mating, and thus bringing into being the particular future in which such future individuals exist (rather than others who live in a different future). But they cannot apparently change how such future individuals fare once they are in existence, by making them either better off or worse off than they are. (This is a version of the celebrated Non-Identity Problem, made famous by Derek Parfit in *Reasons and Persons.*) (Derek, 1984)

From this, it appears to follow that the Precautionary Principle cannot apply to unconceived future individuals, as opposed to present individuals and future individuals who have already been conceived. But there are in fact other differences that present agents can make to unconceived future individuals, through, for example, leaving whoever lives in future times a relatively polluted or a relatively unpolluted environment, or, to return to the language of future scenarios or worlds, through making the future scenario or world in which they exist a relatively polluted or a relatively unpolluted one. As Derek Parfit expresses matters, present agents can affect their quality of life, as well as their identities. (For present agents can bring it about that, whoever lives in the future, their quality of life is better or worse than the quality of life of individuals living in other futures, e.g. through the quality of the environment which present agents bequeath to actual future people.) And Parfit further holds that, although we cannot have obligations that are owed to future individuals as individuals, as their identity is currently neither known nor determined, we can have obligations in their regard, for example, an obligation not avoidably to reduce their quality of life.

Granted that present agents plausibly have obligations of this kind, it becomes possible to interpret the Precautionary Principle so that it becomes relevant to unconceived future people as well as to current people and identifiable future ones. What we need to do is to interpret "serious and/or irreversible damage" as "serious and/or irreversible damage or harm to individuals who exist or have been conceived already, plus serious or irreversible reductions of the quality of life of unconceived future individuals." Thus, although these latter future individuals cannot literally be harmed, it is possible to have and to honor obligations in their regard, obligations not to reduce their quality of life. Indeed this turns out to be an equivalent obligation to the obligation not to harm or damage current individuals. Interpreted in this way, the Precautionary Principle becomes relevant to impacts of present action and inaction on future people, both those already conceived and those unconceived.

But this means that the Precautionary Principle needs to be interpreted as concerned with all the foreseeable impacts of present actions, both those

affecting the living, and those that will make a difference to future quality of life, as far into the future as can be foreseen. Instead of the Non-Identity Problem implying that the Precautionary Principle applies to the individuals of the next century only, the Principle, as newly interpreted, applies to all the foreseeable impacts of present action and inaction, and is therefore relevant to all the impacts of present agents on our successors as well as our contemporaries.

In view of the wide range of applications to which the Precautionary Principle is relevant, it is already clear that this Principle should be included in the training of all students of engineering. This is both an ethical "should" or "ought," and a requirement of consistency for all the states (the great majority of states on the planet) which signed the Rio Declaration of 1992. Such training could usefully include coverage of problems like the thalidomide tragedy, which could have been prevented if the Precautionary Principle had been recognized and in force in international law a few decades earlier than it was.

GLOBAL CLIMATE CHANGE AND ITS IMPLICATIONS

Further areas of common morality need to be embodied in current decision-making, including that of engineers, in view of the phenomenon of global climate change. Successive reports of the Intergovernmental Panel on Climate Change reflect the scientific consensus or near consensus that there has been a steep increase in greenhouse gases (including carbon dioxide and methane) in the atmosphere since the industrial revolution, and that this increase is largely due to human activity; in other words, climate change is largely anthropogenic (Houghton, 2004). Where pre-industrial levels of greenhouse cases stood at 280 parts per million of carbon and carbon-equivalent greenhouse gases, current levels stand at 390 parts per mission or more, and have already briefly fluctuated up to and past 400.

These changes are bringing, where they have not already brought, a whole catalogue of misfortunes. Sea and ocean levels are rising, flooding low-lying coastal communities and small islands, some of which are ceasing to be inhabitable. Threatened installations include nuclear power stations and stores, deliberately situated as they usually are alongside coastlines. Extreme weather events such as hurricanes, floods, and wildfires are becoming more intense and at the same time more frequent. Many species are perforce required to move toward the pole of their hemisphere, and in some cases are running out of habitats. Vector-born diseases such as malaria and dengue fever are rising both in altitude and latitude, as climates become more hospitable to their vectors. And as many areas of land become less cultivable, millions of people are obliged to migrate within or between countries, becoming environmental refugees.

The ethical case for halting these trends, or avoiding them becoming worse, and for rescuing potential victims from their worst effects, is a strong one. In some cases, such actions are a matter of benevolence, comparable to famine relief, informed by foresight, as the welfare of future as well as current generations is at stake. But considerations of justice supplement the ethical case. Thus, it is profoundly unfair that many of the contemporary victims of climate change have contributed little or nothing to the problems, and have had no choice about residing where (say) floods or storm-surges threaten or overpower their homes and their communities. Further considerations of justice indicate that future people should not find that the world they inherit has become less habitable, and the ecosystems on which their predecessors were able to rely have become unreliable and potentially threatening if not deadly. Non-human species too deserve some degree of ethical consideration, whether this too is a matter of benevolence, or (as some of use claim) of justice, or (instead or as well) or

self-interest for those in positions to prevent or alleviate the problems.

Human decision-making is related to these changes in two ways. First, there are the decisions and policies that contribute to the problems, such as energy policies and the long-distance transport of goods that could be produced locally. Then there are the decisions and policies required as countries attempt either to mitigate their contributions to climate change, through, for example, the introduction of renewable energy generation, or to adapt to its impacts, such as through the construction of coastal defences. Engineering decisions figure in both connections, and often involve determining which of the alternative technologies are going to prove sustainable. For unsustainable projects and policies are seldom going to be worthy of selection in view of their limited survival prospects.

The requirement of sustainability, indeed, would be an important one even in other circumstances, in which climate change was less in evidence than it is. But as things stand, it would be reckless to ignore both the background problems, and the pervasive significance of sustainability when it comes to responding to them or to solving them (to the extent that solving them is possible). In general, it can be concluded that the ethics of climate change together with the general ethical contours of possible solutions should be studied by all engineers, so that the advice they give to clients, including local authorities and national governments, reflects a deep-seated awareness of these issues, and does not stop short at professional competence. Otherwise, we are likely on course for a professionally engineered world of considerable and foreseeable catastrophes waiting to happen.

THE FURTHER BEARING OF THE PRECAUTIONARY PRINCIPLE

So far, I have presented the case for the inclusion in engineering ethics of both the precautionary principle and, in connection with the ethics of climate change, the principles of common morality such as benevolence and justice that underpin that area of ethics (as well as others). It remains to comment on the relation of the first to the second, and to explain how the precautionary principle is relevant not only to the areas employed above to illustrate it, but to the major areas of decision-making relevant to climate change ethics as well.

The Precautionary Principle is an ethical principle relating to decision-making in circumstances where there is an absence of full scientific consensus, and this may well be relevant to the field of climate change. For, although there is a strong consensus about the anthropogenic nature of climate change among the vast majority of scientists, there remain sceptical voices. What these voices say varies. Some accept that climate change is happening, but dispute that it is anthropogenic.[3] Others claim that the rate of climate change has been exaggerated,[4] and thus that, even if such climate change as there is, is anthropogenic, the extent and degree of human responsibility should be regarded as less than the standard view maintains. Other sceptics again suggest that, although climate change is both real and anthropogenic, action should be deferred until better technology becomes available, and that current resources should be dedicated to other cause and projects.[5] This third variety of sceptic does not disagree with the standard view of climate change, but differs from most of its holders about whether current action is indicated.

Now the fortunes of the different groups of sceptics fluctuate, but it is unlikely that any of them will disappear altogether, not least because they often enjoy significant financial support from interested corporations, who may or may not have vested interests in action being deferred. In these circumstances, what is needed is a principle relevant to decision-making in circumstances where scientific consensus is absent or incomplete, and this is precisely what the Precautionary Principle supplies. This principle, as was remarked earlier,

does not counsel inaction simply because action could imaginably have worse consequences than inaction would. Instead it urges the need for preventive action where there are reasons (short of scientific consensus) to believe that inaction will produce serious or irreversible harms or reductions of quality of life.

But none of the sceptical factions can claim that there is no such reason, in view of the multiplicity of phenomena indicative of climate change (for example, reductions of Arctic and Antarctic ice, and the increasing incidence of extreme weather events), and the correlation between these phenomena and increasing emissions of (for example) carbon dioxide. Even if other explanations are in theory possible, and have some degree of support (for example, solar activity is sometimes put forward as the driver of climate change), the proposition that there are reasons to believe that significant climate change is both real and anthropogenic simply cannot be denied.

Hence, the appeal to the Precautionary Principle, which we have already seen to be importantly relevant to other areas of engineering decision-making, turns out to be important to the ethics of climate change as well. It does not specify what action should be taken, or by whom, and these are matters to be resolved through the application of other principles, such as principles of benevolence and of justice. But it does clearly indicate that inaction in face of climate change would be wrong. And that would be sufficient to make it one of the key principles of engineering ethics, even if it were not regarded as such a key principle already. The Precautionary Principle, then, turns out to be a central principle for this area of engineering decision-making as well as for many others.

HUMANITY'S CARBON BUDGET

Besides heeding the principles discussed earlier, certain factual findings of recent research need to be taken into account in much decision-making about energy, housing, and transport policies, not least by engineers. These findings can effectively be summarized in the phrase "humanity's carbon budget."

Recent international climate summits, despite their failure to agree an international plan for climate change mitigation, have agreed on the goal of preventing an average increase in global temperatures of above 2 degrees (Celsius). Meanwhile researchers have investigated how many tonnes of carbon and carbon equivalent gases can be emitted as a result of human activity while restricting the probability of exceeding this goal to 50%. The resulting figure is one trillion tonnes. This is the maximum for all time for anthropogenic emissions, if there is to be a 50% chance that average temperatures will not exceed the agreed goal, and so calling it "humanity's carbon budget" makes good sense. For a 75%, rather than a 50% chance, the budget is much lower, but compliance with any significantly lower budget has by now become close to impossible (Meinhausen et al., 2009).

In view of the trillion tonnes ceiling, it is worth asking what proportion of this maximum total of permissible emissions has been used up already, or what the extent of historical emissions to date has been, as a proportion of this total. The same researchers here come up with a figure of 55%; we have already used up well over half of humanity's carbon budget. Indeed at current rates, the rest of the all-time carbon budget will be used up within three decades (Meinhausen et al., 2009).

Granted further the serious character of the impacts of climate change, as rehearsed earlier, it has become imperative not to exceed the global carbon budget. This has become imperative if we are to heed the requirements of justice toward contemporaries, both human and non-human, and the interests of both our human and our non-human successors of future generations. But as known reserves of hydrocarbons would, if used, take us far beyond this budget, it has also become imperative not to deploy all these reserves, but to

leave a large proportion of them in the ground. Indeed ethical investment groups have recently been seeking to explain that these apparent stocks of resources are often illusory, as in large measure it would be disastrous to use them.

This conclusion has some possibly surprising implications in its turn. For, if existing hydrocarbon resources are largely unusable, then it must be questionable to seek to increase them. It does not follow that this would be entirely mistaken, for the newly found resources might prove easier to access than those found previously. But attempts to extract hydrocarbons through extreme methods such as mining in the Arctic, beneath the beds of oceans, or (as is projected) beneath the bed of the Arctic Ocean do turn out to be misguided, as the outcome of all the effort involved it to supplement resources, of which we have too much already.

Decision-making about new sources of energy should take all this into account, as drilling in the Arctic is not the only form of extreme extraction. Another is tar sands extraction, which appears in addition to have strongly adverse impacts on previously healthy environments. Further, at least some forms of shale gas extraction may well fall into the same category. A likely example is fracking. Whereas fracking is sometimes opposed on environmentalist grounds, the basic objection is that the effort and the risks involved are likely at best to increase supplies of hydrocarbons of which humanity has too many already. It would be far preferable for decisions about energy supplies to focus on renewable forms of energy generation, as these lie outside humanity's carbon budget.

Accordingly, certain forms of energy generation that might appear to be morally neutral turn out probably to be morally unjustifiable. I have argued that most forms of extreme extraction turn out to be relevant examples.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

Engineering ethics has been found to extend far beyond the realms of professional competence and professional ethics. Engineers need to be aware of principles of common morality such as benevolence and justice, and also to be aware of principles embedded in international law, such as the Precautionary Principle. Various applications of these different principles have been presented. The Precautionary Principle has been argued to be applicable not only to standard cases of decision-making against a background of uncertainty, but also to decisions in the realm of the ethics of climate change.

In the section of this chapter on "Humanity's Carbon Budget," the importance of humanity's carbon budget was brought into focus. The goal of not exceeding this budget can be supported by a range of ethical considerations, of benevolence, justice, and precaution. But for practical purposes, it may be best to declare this goal a principle itself (albeit a subordinate one). Accordingly, engineers, like other members of society (and members of governments) should observe the Principle of Compliance with Humanity's Carbon Budget, as well as the other principles for decision-making presented here. This principle is probably less well known than the others, but is not for that matter any less important.

In future research on engineering ethics, the task of integrating professional aspects of engineering ethics with aspects arising form the Precautionary Principle and from Humanity's Carbon Budget could beneficially be undertaken. Common principles of ethics, such as benevolence and justice, should also be included. In these ways, engineering students could be equipped from the earliest stages of their training with a clear view of the ethical aims, principles, and constraints relevant to their work as professionals and as citizens; nothing less than this will be adequate for the engineers of tomorrow as they embark

on careers involving addressing problems local, national, and global.

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1 Parker, J. (1998). Precautionary Principle. In R. Chadwick (Ed.), *Encyclopaedia of applied ethics* (pp. 633-641), Vol. 4. San Diego: Academic Press, p. 634. See also Robin, A. (2012). *Ethics: An overview*, London: Continuum/Bloomsbury, p. 106.

2 Parker, J. (1998). Precautionary Principle. p. 634. See also Robin, A. (2014) *Environmental ethics: An overview for the twenty-first century*, 2nd edition, Cambridge, MA: Polity Press. For the Rio Declaration, see Louis P. P. (1994). *Environmental ethics: Readings in theory and application.* Boston, MA: Jones and Bartlett, pp. 501-503.

3 A leading example is Dr. S.Fred Singer.

4 The most prominent example in United Kingdom is the former Chancellor of the Exchequer, Sir Nigel Lawson.

5 A prominent example of this stance is Björn Lomborg's work, *The Sceptical Environmentalist: Measuring the Real State of the World*, Cambridge University Press, Cambridge, 2001.

Chapter 5
Ethics is not Enough:
From Professionalism to the Political Philosophy of Engineering

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ABSTRACT

This chapter argues for understanding engineering ethics in terms of three principles—but then going beyond ethics to political theory. A simplified prefatory comparison between engineering and science points to the importance of ethics in engineering. Section 1 provides a historico-philosophical overview of engineering ethics in the United States, on the premise that American experience can be generally illuminating. The narrative traces a trajectory of commitments from company loyalty to public responsibility, with the public responsibility promoting public engagement. Section 2 considers three influential American cases that together suggest a duty to public disclosure. Section 3 broadens the analysis through selective reviews of engineering ethics profiles in Germany, The Netherlands, Japan, Chile, and in transnational professional engineering organizations, on the basis of which is articulated a duty not only to avoid harm but also to do good. Section 4, a critical reflection on engineering in the intensive form of research and design, posits a synthesis of the principles of participation, disclosure, and beneficence into a duty plus respicare, to take more into account. A concluding section nevertheless suggests the inadequacy of limiting engineering ethics to ethics. Ethics in engineering like ethics generally implicates political theory. Ethics in the absence of politics demands unrealistic personal heroism; political theory without any foundation in ethics promotes tyranny.

INTRODUCTION

Humans have since antiquity undertaken projects that are now often interpreted as works of engineering, but the first engineers as such did not appear before the Renaissance. In the centuries since there has been increasing recognition that the powers possessed by modern engineers as a result of their expertise call forth special moral obligations or responsibilities. Critical reflection on such responsibilities is known as engineering ethics, and the associated efforts to articulate and apply engineering responsibilities are topics of ongoing discussion. Insofar as people in

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the contemporary world have become users of engineered artifacts and live out their lives in engineered worlds, there is a sense in which they too have new responsibilities, so that engineering ethics is for everyone. What follows is an effort to review the historico-philosophical development of engineering ethics as this discourse emerged from the United States in a way that can inform not only professional engineers but also all reflective consumers, users, and citizens in a technoscientific world. In the end, however, ethics is not enough. What is called for is a political philosophy of engineering.

PROLOGUE: IN PLACE OF DEFINITION

To focus on engineering as such requires a preliminary definition. Yet clear and distinct definitions are not only difficult to come by, they may also precipitously narrow reflection. Mindful of this danger, but cognizant that understanding advances by comparison and contrast, it is useful to begin with some provisional reflections on relationships between engineering and its near neighbor science.

"Scientists discover the world that exists; engineers create the world that never was." This statement, commonly attributed to aeronautical engineer Theodore von Kármán,[1] offers a soft definition of engineering as creative of new things. Although obviously true to some extent, the statement is too general; craft, the arts, and revolutionary politics all create things that did not previously exist. But taking off from von Kármán's analysis of relationships between mathematics (as a science) and engineering,[2] science can be described as a disinterested pursuit of knowledge or truth especially manifested in research that leads to publication. Unlike engineering research, there is no explicit commitment to practical value—although science is often thought to have indirect or spin-off value for engineering, economic development, and other practical activities. By contrast, engineering is explicitly oriented toward the design and creation of physical artifacts, which, in capitalist society, are often patented or protected by trade secrecy laws. In popular thought, the scientist is imagined as university based, whereas the typical engineer owns or works for a business firm or the government. Compare, for example, the image of Albert Einstein with those of Nikola Tesla and Werner von Braun (James, 2010). Explicit codes of conduct are neither as old nor as diversely articulated in science as in engineering,[3] with the most widely discussed ethical conduct issues in science being fabrication, falsification, and plagiarism in the reporting of research, whereas with engineering they are the sign and production of dangerous (unsafe) structures, processes, or consumer goods and whistle blowing. Such contrasts are summarized in the following table:

However simplified or incomplete, such comparisons provide a preliminary orientation for reflecting on engineering ethics. Following a historico-analytic narrative, attention will turn to three representative case studies, which will then be complemented by descriptions of different approaches in the United States and other countries. This scope and focus will feed into the question of ethics in relation to, especially, engineering design research. Contemporary scientific engineering would not be what it is without engineering research as well as an adoption of the research ethos—all of which has implications for those of us living with, benefitting from, and being transformed by science and technology.

1. A HISTORY OF IDEAS IN ENGINEERING ETHICS

As noted, engineering is a profession of relatively recent origin. By contrast, the classic secular professions of medicine and law have pre-modern roots. If one dates the birth of modern natural science as a social institution from the founding of the Royal Society in 1660, engineering as a civilian

Table 1. Science vs. egineering

ETHICS *Related to:*	**IN SCIENCE**	**IN ENGINEERING**
Goals	Knowledge or truth and- publication	Practical effectiveness and patents
Ethics Codes	More implicit	More explicit
Institutional Base	University or government-corporate research centers	Development or manufacturing divisions of business firms
Public Issues	Research fraud or misconduct	Unsafe designs and whistle blowing

profession may be historically anchored in John Smeaton's informal convening of the Society of Civil Engineers a hundred years later in 1771, which led to the royal chartering of the Institution of Civil Engineers (ICE) in 1828. Likewise, just as one distinguishing feature of modern natural science is the publication of research, which began in a systematic way with the Philosophical Transactions of the Royal Society in 1665, a key aspect of engineering in the modern sense is the patenting of inventions, which did not become widely protected by national statute law until, for example, 1790 in the United States and 1791 in France. Since then, over the course of the next two hundred plus years, there have emerged three overlapping ideals of ethical responsibility in engineering.

Obedience to Authority and Company Loyalty

Engineering as a civilian profession in the West arose out of the military, and the military ethos of obedience to authority exercised a formative influence on engineering conceptions of responsibility. The fourth-century Roman soldier–historian Ammianus Marcellinus in his Rerum gestarum (XXIII, 4) describes military ingenia such as the ballista and battering ram. A thousand years later the builder of such devises had come to be called an ingeniator. The "engineer" in this sense was initially a soldier who designed military fortifications and/or operated engines of war. William Shakespeare refers to Achilles as "a rare engineer" (Troilus and Cressida, act 2, scene 3, line 8) and writes of a soldier "engineer/Hoist with his own petard" (Hamlet, act 3, scene 4, line 206).

The initial institutions of engineering education were also embedded in the military:

- Czar Peter the Great's Academy of Military Engineering (Moscow, 1698);
- Emperor Joseph I's Estates School of Engineering (Prague, 1707);
- The Bureaux des Dessinateurs du Roi (1744), which became the École des Ponts et Chaussées (Paris, 1747);
- The École des Mines (1783);
- The École Polytechnique created by the National Convention of the French Revolution (1794); and
- The United States Military Academy at West Point founded by President Thomas Jefferson (1802).

The École des Ponts et Chaussées and École des Mines were established to educate members of a regimented national corps of road builders and mining specialists, respectively; the École Polytechnique was placed at the service of Napoleon Bonaparte shortly after he became Brigadier General of the Revolutionary Army of the Republic. The Military Academy at West Point was the first school in the United States to offer engineering degrees; General Sylvanus Thayer, creator of the West Point curriculum subsequently endowed

the Thayer School of Engineering at Dartmouth College. Within such contexts, the general duty of engineers, as with all soldiers, is to defend the state in a hierarchical institution with a disciplinary ethos of obedience to authority.

During the same period as the founding of the first professional engineering schools, a few designers and builders of "public works" began to distinguish themselves from their military forebears with the term "civil engineer"—a designator that continues in some contexts to denote all non-military engineering. The creation of this civilian counterpart to military engineering—defined in the ICE Royal Charter as "the art of directing the great Sources of Power in Nature for the use and convenience of man"[4]—initially gave little cause to alter the basic sense of engineering responsibility. Civil engineering was simply peacetime military engineering for "use and convenience" (a term influenced by David Hume's moral theory[5]) and engineers remained duty-bound to obey their employers, whether a non-military branch of government or a private corporation.

The late 18th and early 19th centuries also witnessed the growth of public associations of professionals (such as physicians, lawyers, and engineers) in what Alexis de Tocqueville described as social (rather than economic) organizations intermediate between family and state—and as the foundational institutions of civil society.[6] During the same period, technical knowledge became increasingly rationalized in various semi-autonomous disciplines, reflecting what sociologists identify as a key feature in the logic of modernity, structural differentiation.[7] Intermediate associations of engineers thus formed to reflect disciplinary differentiations of civil, mechanical, electrical, chemical, and other branches of engineering.

Historically, ethics too became an issue for differentiation. The American Medical Association at its founding in 1847 drafted a "Code of Medical Ethics," made a link to the premodern "Oath of Hippocrates" (from the 5th century BCE), and framed obligations to patients and the public good in terms of relieving suffering and securing health. The American Bar Association, three decades after its 1878 founding, in 1908 adopted a "Canons of Ethics" that framed obligations to clients and society as promoting justice. During the opening decades of the 20th century, professional engineering societies likewise began to formulate ethics codes which, naturally enough, tended to make explicit what had previously been implicit: loyal obedience. Although all three regionalized ethics codes highlighted obedience, the medical and legal professions made themselves subject to individual patients and clients in the furtherance of general ideals (health and justice). By contrast, engineering codes placed engineers under the authority of corporate employers without any explicit reference to a technical ideal. It is actually surprising that no reference was made to the ideal of "use and convenience" included in the original ICE definition.

Primary examples are the codes of ethics of the American Institute of Electrical Engineers (AIEE, later to become the Institute of Electrical and Electronic Engineers or IEEE) adopted in 1912, of the American Society of Civil Engineers (ASCE) and the American Society of Mechanical Engineers (ASME), both of which were adopted in 1914. Each of these three codes was less than a page in length and stressed that "the engineer should consider the protection of a client's or employer's interests his first professional obligation" (to quote the AIEE) or required the engineer to act simply "as a faithful agent or trustee" (ASCE language).

With regard to the ASCE, Sarah Pfatteicher has insightfully uncovered conflicting influences active in the emergence of its code and in the internal discussions that extended from the 1870s to the early 1900s. As she has argued:

the first code of ethics adopted by the ASCE was intended to describe, rather than guide, the behavior of ASCE members. … Early codes of

ethics were intended to document and publicize existing standards of behavior (largely for the benefit of potential employers), not to establish ideals toward which ASCE members might strive (Pfatteicher, 2003, p.21).

This descriptive code admonished members to be true to existing practice and "to be loyal to their clients, their fellow engineers, and their profession (Pfatteicher, 2003, p.21)." Paradoxically, although one goal of this early code construction was to enhance public recognition and a degree of autonomy, because of the prominence given to business interests and company loyalty, the practical effect was to undermine independence. In other words, professional engineering—insofar as it articulated loyalty as a primary value—tended to promote a kind of self-imposed tutelage to corporate employers.

One criticism of this historical narrative deserves acknowledgment. Michael Davis (2002) challenges the idea that engineers initially took loyal obedience as their primary obligation. Such a view, he argues, ignores historical context and the role of interpretation required by any law or code of conduct. Davis's argument makes important points, but historical context also supports a loyalty narrative. Repeatedly in various early twentieth-century engineering society proceedings there is an emphasis on some form of loyalty as primary. For instance, in a proposal leading up to adoption of the AIEE code, it was clearly stated that "the electrical engineer should consider the protection of his client's interests as his first obligation";[8] and in a discussion preparatory to the ASME code, it was proposed that "the engineer should consider the protection of a client's or employer's interests his first obligation, and he should avoid every act contrary to this duty."[9] The fact that loyalty was considered a special problem to be confronted in engineering ethics education in the 1980s is further confirmation of the important role it played.[10] Davis is clearly correct, however, for reasons he fails adequately to reference—that engineers thought such loyalty was in the public interest on the basis of an ideological belief in corporations themselves as public benefactors.

The Principle of Loyal Obedience

There is undoubtedly some value in the related principles of loyalty and obedience. Loyalty is a widely recognized virtue under many circumstances. Without loyalty it is hard to imagine any social relationship, whether personal friendship or larger group solidarities, being sustainable. The problem with any obediential ethics is that it leaves adherents subject to manipulation by forces that may well be unjust. Only when and to the extent that the authority to be obeyed is good, is obediential ethics fully justified. In the Abrahamic religions, where obediential ethics plays a dominant role, it is based on belief in the absolute goodness of the authority to be obeyed. One obeys God because God is wholly good. In any other instance, obedience requires qualification. Even in the military, it is now common to say that one is obligated to carry out only legitimate or just orders. Physicians and lawyers, too, are obligated to respond positively to the wishes of their patients and clients, only to the extent that patients and clients desire health and justice. Attempts to meet the weakness of an unqualified loyal obedience—and to articulate a regulative ideal for engineering comparable to those of health in medicine and justice in law—gave rise to the technocracy movement.

Technocratic Efficiency

Opposed to professional ethics codes stressing obedience and company loyalty is the ideology of leadership in technological progress through pursuit of the ideal of technical efficiency. In 1895, in an ASCE presidential address, George S. Morison, one of America's premier bridge-builders, making implicit reference to the ICE definition, envisioned the engineer in religious terms as the

primary agent of technological change and the main force in human progress. In Morison's words:

We are the priests of material development, of the work which enables other men to enjoy the fruits of the great sources of power in Nature, and of the power of mind over matter. We are the priests of the new epoch, without superstitions (Morison, 1895, p.483).

During the first third of the 20th century in the United States, this vision of engineering activity spawned the technocracy movement and a theory that engineers should be given political and economic power. Political economist Thorstein Veblen, for example, argued that if engineers were freed from obedience to business interests, then their own technical standards of good and bad, right and wrong, would lead to the creation of better consumer products and a more sound economy.[11]

The principle of efficiency: Again, there is some value in the arguments for such technocratic leadership and the pursuit of efficiency. Certainly, the subordination of production to short-term money making without concern for the good of the products being designed and manufactured is not desirable in the long run, and inefficiency or waste can be described as types of imperfection if not evil. Moreover, in a highly complex techno-scientific world it is often difficult for politicians or average consumer–citizens to know what is in their own best technical interests. And, whether efficiency can be adequately promoted either by the consumer pull of imperfect markets or by a push from technical professionals under the thumb of corporate interests remains seriously questionable.

Nevertheless, to govern in pursuit of technical efficiency is problematic on at least three counts. First, efficiency as an ideal only functions within well-defined boundary conditions that are often surreptitiously set by non-engineers and may exclude important factors. Limitations in perspective can occur even when engineers set their own boundary conditions for conducting input–output analyses, given a training and mindset that emphasizes problem quantification. Second, the pursuit of technical perfection in the form of maximum output for a given input is not always the best use of societal resources—as when, for example, cars are increased in efficiency at the expense of designing a constructing public transport systems. Third, technocratic decision making by engineers is obviously in tension with democratic decision-making. In response to such objections there developed a third distinct idea of engineering ethics, that of the public good understood in terms of public safety, health, and welfare.

Public Safety, Health, and Welfare

The World War II mobilization of science and engineering for national purpose in the United States and the North American post-war recovery contributed to a temporary suspension of tensions between technical and economic ends, efficiency and profit, that had been highlighted by the technocracy movement. But, the anti-nuclear weapons movement of the 1950s and 1960s, in conjunction with the consumer and environmental movements of the 1960s and 1970s, brought tensions again to the fore and provoked some engineers to challenge national and corporate or business direction. In conjunction with a renewed concern for democratic values—especially as a result of the civil rights movement—this led to a new interpretation of the engineering use and convenience ideal.[12]

Seeds of this transformation were planted immediately after World War II when in 1947 the Engineers' Council for Professional Development (ECPD, founded 1932) drew up the first trans-disciplinary engineering ethics code, committing engineers "to interest [themselves] in public welfare." Revisions in 1963 and 1974 strengthened this commitment to the point where the first of four "fundamental principles" required engineers to use "their knowledge and skill for the enhancement of human welfare," and the first of

seven "fundamental canons" stated that "Engineers shall hold paramount the safety, health and welfare of the public." This position was reaffirmed in 1977 and the code continued to be presented as a model when the ECPD became the Accreditation Board for Engineering and Technology (ABET) in 1980 (although it was subsequently dropped as a model code in favor of a code that applied to ABET itself and was incorporated into a set of "Rules of Procedure").

This third distinct idea of engineering ethics meets many of the objections that can be raised against the first two, and has been widely adopted by the professional engineering community both in the United States and elsewhere. It also allows retention of desirable elements from prior theories. For instance, loyal obedience remains, but within a larger or more encompassing framework. Now the primary loyalty is not to some individual or corporation but to the public as a whole. Leadership in technical development likewise remains, but is explicitly subordinated to the common good, especially in regard to health and safety.

Environmentalism and Sustainability

In the 1980s, there were efforts to expand this interpretation of use and convenience as public safety, health, and welfare further to include the natural environment. American engineer Aarne Vesilind and New Zealand philosopher Alastair Gunn have observed, however, that the integration of environmental ethics into engineering ethics was complex and contentious, driven as much by external political forces as by internal professional concerns.[13] In 1990 the IEEE "Code of Ethics" adopted an explicit reference to the environment, but in a weak form by elaborating an obligation "to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public" to include an obligation to disclose dangers to "the public or the environment." Then in 1997 the ASCE—which had previously included a version of the ABET fundamental principles, with an added reference to the environment—endorsed the political emergence of sustainability as a conceptual restatement of environmentalism. Its first fundamental canon became that "Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development."[14] In short order, a National Academy of Engineering (NAE) report on the "engineer of 2020" likewise subsumed environmentalism under the sustainability rubric.[15]

A Participation Principle

Concern for the public good, including the environment and sustainability, does not necessarily involve any citizen participation in decision-making. A technocracy/democracy problem remains. The engineer committed to public safety, health, welfare, and sustainable development may make decisions about technical issues in an authoritarian manner at odds with democratic ideals, based on a strictly technical analysis and evaluation of risks associated with some product or process. Vesilind and Gunn (1998) even go so far as to argue, not unlike Morison, that since "engineers are often the only people with the knowledge of potential environmental harm and the professional authority to command attention [that] this gives them more environmental responsibility" than others and that "engineers are in a unique position to make a difference in the care and nurturing of our planet."

Yet recognition that technology often brings with it not only benefits but also costs and risks argues for granting all those affected some input into technical decisions. On the basis of a proposal to understand engineering as social experimentation, the philosopher–engineer team of Mike Martin and Roland Schinzinger argue for adaptation of the biomedical ethics model of human subjects research that requires free and informed consent of all participants.[16] Deploying a more political analogy, political theorist Langdon Winner and philosopher Steven Goldman have argued a prin-

ciple of "no innovation without representation."[17] Participation has become a widely defended ideal but incorporated into engineering ethics only to a limited extent.[18]

One important qualifier is that participation need not imply veto power, but only intelligent and relevant involvement in decision-making. Equity (a stake in the game) is not the same as equality (an equal stake). In accordance with a participation principle, the role of the engineer as technical specialist becomes not so much that of independent adviser or decision-maker as one of participant in an educational dialogue and contributor to various regulatory processes within appropriate democratic structures and guidelines. The ideal of responsibility for the public good, especially as extended with the participation principle, has nevertheless been circumscribed by considerable debate concerning theoretical justifications and practical implications. Practical questions are present in a series of case studies that have figured prominently in efforts to teach engineering ethics.

2. ENGINEERING ETHICS: AMERICAN CASES AND ISSUES

The fundamental practical problem for the engineering community has been how to develop an autonomy that would enable engineers to practice a professional commitment to the primacy of public safety, health, and welfare without undermining appropriate company loyalty or subverting democracy. The problem is that engineers are often granted the power to make technical decisions for the public that can easily lead to the promotion of non-public interests. One of the most influential of these "conflicts of interest" is known as the Hydrolevel case. At the same time, in comparison with scientists, engineers are more "on tap than on top."[19] This fact has been driven home by a number of case studies of disasters associated with design flaws resulting in disasters such as those involving Goodrich A-7D airbrakes,[20] cargo bay doors on the DC-10 (Fielder & Birsch, 1992), gas tanks on the Ford Pinto (Birsch & Fielder, 1994), and others. Two of the most widely influential such disaster cases concern the Bay Area Rapid Transit (BART) system and the space shuttle Challenger.

Hydrolevel Case

In the early 1800s, in response to an increasing number of public fatalities resulting from steamboat boiler explosions, the U.S. government awarded the first research contract to the Franklin Institute, an educational and research organization founded in 1824 "for the promotion of the mechanic arts." This research disproved a number of then current theories (for example, that water at high temperature in a boiler can decompose into hydrogen and oxygen and then explode) and pointed out the need for better materials standards in boiler construction, regular maintenance, and more adequate safety devices (such as high-pressure release valves).

In response, by the mid-1800s Congress had enacted regulatory legislation.[21] As they evolved, the regulatory agencies that were established became the enforcers of technical standards, which by the early 1900s, had become the responsibility of the ASME. In the process, research engineers, in a benevolent technocratic manner, had clearly taken on a responsibility for helping to protect public safety and welfare.

By the mid-1900s, however, this responsibility and relationship had become incestuous. In the late 1960s research at a small engineering firm, Hydrolevel Corporation, developed a new type of low-water fuel cutoff device for steam boilers that threatened the business of McDonnell and Miller, Inc. (M&M), the primary supplier of such devices. When an appeal was made to the ASME for an interpretation of section HG-605a (a 43-word paragraph) in its 18,000 page Boiler and Pressure Vessel Code that would certify the new Hydrolevel design, ASME members who

were also involved with M&M acted to secure a negative response. The result was a lawsuit that went all the way to the Supreme Court, which in 1982 ruled that ASME had violated the Sherman Anti-Trust Act. (Hydrolevel also eventually went out of business because it could not market its new product.)[22] A commitment to protect public safety and welfare through technical ideals and engineering autonomy had been used to protect the welfare of a private engineering-based firm.

Bay Area Rapid Transit (BART) Case

In the late 1950s metropolitan San Francisco decided to create the Bay Area Rapid Transit (BART) system, designed to be the most advanced metro in the world—one that would eliminate both operators and conductors in favor of an automatic train control (ATC) process. The proposal involved an early effort to design a real-world unmanned transport vehicle. Construction began in 1964 and at the end of 1971, almost three years behind schedule and considerably over budget, BART was finally nearing the first stage of completion.

During this time, however, Holger Hjortsvang, a research engineer working on the ATC, became seriously concerned about its design and testing—especially the attempt to deal with problems in a complex project on a piecemeal rather than a systemic basis. Beginning in 1969, he expressed these concerns to management, and by late 1971 found himself supported by two newly hired engineers: Max Blankenzee, a senior programmer analyst, and Robert Bruder, an electrical–electronics construction engineer, both of whom were also involved with the ATC. For months, the three engineers expressed their concerns to management both orally and in writing, only to have them consistently ignored.

Finally, seeking to have their concerns addressed, in early 1972 the engineers contacted a member of the BART District Board of Directors and provided papers documenting their case. Very shortly there were unexpected newspaper stories on the problems (a board member, despite promising the engineers confidentiality, had leaked to the media), followed by a February meeting of the Board that yielded a split vote of confidence in BART management. Management then undertook to identify the sources for certain critical documents provided to the board and at the beginning of March fired Hjortsvang, Blankenzee, and Bruder.

The engineers then appealed for support to the California Society of Professional Engineers (CSPE), arguing that they were only attempting to live up to an ethics code obligation to hold "the public welfare paramount" and to "notify the proper authorities of any observed conditions which endanger public safety and health." In June, the CSPE submitted a report to the California State Senate largely supporting the engineers. Then in October, in dramatic confirmation of the engineers' concerns, an ATC failure cause a BART train to overrun a station, injuring four passengers and an attendant.

Prior to the BART case, the primary way in which professional engineering societies had acted to enforce ethics codes had been to discipline engineers for disloyalty to an employer—often by expelling them from a professional society. The BART case was the first in which a professional engineering society publicly backed its members and criticized a specific firm. A further supportive report by the IEEE, the largest engineering society in the world, led to the creation of an Award for Outstanding Service in the Public Interest—which was first given in 1978 to the three BART "whistle-blowers."[23]

Challenger Case

In 1986, the need for engineering independence was again brought to professional and public attention by the space shuttle Challenger disaster. Once more a major high-tech, government-funded project was years behind schedule, considerably over budget, and thus subject to strong management pressures to meet new and unrealistic dead-

lines. As came to light afterward, Roger Boisjoly, a mechanical engineer at Morton-Thiokol in charge of design for the field joints on the solid rocket booster, had been questioning the safety of o-ring seals for almost a year. The night prior to the January launch, Boisjoly and other engineers had explicitly opposed continuing the countdown, only to have their decision overridden by senior management.

As a result of their testimony before a Presidential Commission during its post-disaster investigation, these engineers came under severe pressure from Morton-Thiokol to defend the company. But, Boisjoly became an outspoken advocate for both greater autonomy in the engineering profession and the inclusion of engineering ethics in engineering curricula, thus helping to promote development of engineering ethics courses in engineering colleges throughout the U.S.[24]

Whistle Blowing as a Duty to Public Disclosure

Uniting these three cases is not only the practical problem of developing or promoting the right kind of engineering autonomy, but also what might be called a principle of public disclosure—one clearly allied with that of public participation. Supporting such a principle is the argument that public good is served by a duty to disclose both the full process of technical decision-making and any shortcomings in relationship to safety, health, welfare, and the environment—especially to those who might be effected.

With the Hydrolevel case, for instance, a more forthright disclosure of personal interests might well have led to a different outcome early in the technical standards definition process. With both the BART and Challenger cases, public disclosure was a principle underlying the actions of the engineers involved—although with Hjortsvang, Blankenzee, and Bruder disclosure took place before the accident, whereas with Boisjoly it took place after the fact. In all three instances, it is also reasonable to argue that the engineering design work deserved disclosure, because in the Hydrolevel case it supported safety with enhanced efficiency of operation and in the BART and Challenger cases it was research by especially Hjortsvang on the ATC and by Boisjoly on the o-ring seals, which founded their beliefs that safety was being compromised.

Compare, too, the situation of physicians and lawyers with engineers, in regard to respective responsibilities to those for whom they provide professional services. One aspect of such responsibilities for physicians and lawyers is a responsibility to protect patient and client confidentiality. The physician is obligated not to reveal the state of health of a patient to others without patient consent; an attorney is not permitted to share knowledge about the guilt of a client without client consent. Exceptions occur, however, when patient illness endangers public health and when clients reveal plans to commit a crime. In such cases, where the professional has knowledge about what might happen in the future, as opposed to what has happened in the past, the obligation to uphold confidentiality weakens if not vanishes. Since what engineers often know is not just the past but the future, a prima facie duty to public disclosure is likely to be present.

But the hypothesis of a duty, under certain conditions, to disclose engineering knowledge must not be too quickly affirmed without recognizing a possible tension between duties to truth or knowledge and duties to welfare or the good. Earlier it was remarked that the duties to knowledge are characteristic of science, whereas duties to good use are more prominent in engineering. In the free market economic system, corporations are also generally granted legal protection for trade secrets—that is, granted the right not to disclose knowledge or information of a certain type—in the belief that this will promote invention and therefore societal welfare. But knowledge that is publicly disclosed can no longer be protected under trade secrecy laws, so that corporations have

a reasonable interest in requiring that engineers not reveal knowledge except when necessary to secure a patent or pursue other business purposes. Engineers, unlike scientists, typically do not publish their work. The resultant tradition of engineering secrecy is thus at least in tension with any duty to disclose knowledge related to issues of safety, health, and welfare.

3. ENGINEERING ETHICS OUTSIDE THE UNITED STATES

Although case studies call attention to some of the distinctive features of engineering experience, as the discussion of a possible duty to public disclosure indicates, cases themselves are no more than starting points for reflective analysis. Moreover, because cases can turn out quite differently under different historical and societal backgrounds, the issues of engineering ethics often exhibit distinctive features across cultural and political geographies. Consider, as examples, different engineering ethics perspectives from Europe, Asia, and Latin America.

Perspectives from Germany

Engineering ethics in Germany, for instance, has a more developed theoretical base than in the U.S. Immediately after World War II, because some of its members had been compromised by involvement with National Socialism, the Verein Deutscher Ingenieure (VDI or Association of German Engineers) undertook to promote general philosophical reflection among engineers. This has led to a more sustained dialogue between engineers and philosophers than in any other country.

In the early 1950s, for instance, the VDI sponsored a series of conferences on "The Responsibility of Engineers," "Humanity and Work in the Technological Era," "Changes in Humanity through Technology," and "Humanity in the Forcefield of Technology." Out of the first conference came "The Engineer's Confession," a Hippocratic-like oath for VDI members, and later the formation of a special Mensch und Technik [Humanity and technology] commission composed of engineers and philosophers. Broken down into a number of working committees on "Pedagogy and Technology," "Sociology and Technology," "Religion and Technology," "Philosophy and Technology," etc., the commission produced by the mid-1970s a number of important studies focusing on technology and values.[25]

This work in turn led to replacement of the now somewhat dated "Engineer's Confession" and to further interdisciplinary engineering-philosophy research, especially on the theoretical basis of technology assessment. Although technology assessment originated in the United States, it emerged there outside the professional engineering, primarily as a social science practice. By contrast, in Germany it became integrated into discussions of professional engineering responsibility. With regard to professional ethics, one Mensch und Technik working committee report in 1980 proposed simply that "The aim of all engineers is the improvement of the possibilities of life for all humanity by the development and appropriate application of technical means."[26] With regard to the foundations of technology assessment, a second working committee in 1986 identified eight fields of value (environmental quality, health, safety, functionality, economics, living standards, personal development, and social quality), mapped out their interrelations, and developed a set of recommendations for their implementation in the design of technical products and projects.[27]

In the early 2000s, this approach led the VDI officially to adopt a statement regarding the "Fundamentals of Engineering Ethics" that involves engineers in human affairs more significantly than any other professional engineering organization in the world. A summary itemizes ten characteristics of professional engineers. Among these, engineers:

- Are committed to developing sensible and sustainable technological systems.
- Are aware of the embeddedness of technical systems in societal, economic, and ecological contexts, and their impact on the lives of future generations.
- Aiscuss controversial views and values across the borders of disciplines and cultures.
- Contribute to defining and developing relevant laws and regulations as well as political concepts.
- Are committed to enhancing critical reflection on technology in schools, universities, enterprises, and professional institutions.[28]

Perspectives from the Netherlands

The Netherlands is arguably the most artificial country in the world. One-fourth of its land area is below sea level, with the percentage increasing as global climate change increases the sea level; the country is thus wholly dependent on the functioning of a mega-engineering project, the Deltawerken, which began as a response to the disastrous storm flood of 1953, but has roots that go back to the 1000s and the emergence of modern hydrologic engineering.[29] Additionally, the Netherlands has the highest population density of any European country with intensive agriculture, transport, and communication infrastructures as well as a highly educated and democratically engaged population. Under such circumstances, the fact that the Netherlands has the most intensive commitment to the philosophy of engineering and technology, with strong ethical and political dimensions, should be no surprise. Especially since the 2007 founding of the 3TU Centre for Ethics and Technology (a collaboration of TU Delft, TU Eindhoven, and Twente University) there are probably more Dutch philosophers of engineering and technology as a percentage of the population than in any other country in the world.

Like the Germans, the Dutch see ethics as one aspect of a comprehensive philosophy of technology involving epistemology, ontology, ethics, and political theory. At the level of practice, engineering ethics courses began to be introduced as requirements into engineering curricula in the 1990s.[30] The Koninklijk Instituut van Ingenieurs (KIvI or Royal Dutch Society of Engineers, founded 1847) in 2006 adopted a "Code of Conduct" that highlighted the role of engineers "as creators and managers [who] carry a special responsibility for people, society, and the environment" and stressed a need for engineers to "respect the cultural values and the populations" of all countries in which they work. Although the American approach to engineering ethics (focused on codes and case studies) has strongly influenced Dutch teaching, the Dutch have placed more stress on the engineering design activity and on integrating human rights and global perspectives (de Poel & Royakkers, 2011).

Perspectives from Japan

In Japan, by contrast, engineering has not always been treated as much as an enterprise separate from science as it has in Europe or North America. Here one of the first and most influential code-like documents was a 1954 "Statement on Atomic Research in Japan" issued by the Japanese Science Council (JSC), which included both scientists and engineers. This statement set forth what have become known as the "The Three Principles for the Peaceful Use of Atomic Energy": All research shall be conducted with full openness to the public, democratically administered, and carried out under the autonomous control of Japanese themselves.

The first two principles provide good illustrations of the participation principle. But since nuclear power can have an impact quite beyond national boundaries, the third somewhat undercuts it. These principles further reflected a desire among Japanese during the 1950s to distance themselves from United States interests and

policy (recall that the Allied occupation ended in 1952). Immediately after World War II, the U.S. had prohibited all Japanese research in aviation, atomic energy, and any other war-related area. But by the mid-1950s, following a Communist victory in China and the outbreak of war in Korea, U.S. policy began to shift toward encouraging certain kinds of military-related science and engineering and the incorporation of Japan into the Western alliance. Indeed, Japanese scientists and engineers recognized that the Three Principles were at odds with, for example, the U.S. policy of secrecy in atomic research. And in order to avoid publicity and the possible development of opposition, the JSC statement was not initially translated into English. It also stated a policy which, although formulated by scientists and engineers, was readily adopted by the government, thus reflecting the social prestige and political influence of the Japanese technical community in comparison with what obtains in some other countries.

The year 1951 also saw formation of Institution of Professional Engineers Japan (IPEJ), which in 1961 nominally adopted a code of ethics. It was not until the 1990s, however, that ethics became a topic of serious discussion among engineers. Under the influence of these discussions and the globalization of engineering practice, in 1999 the Japan Accreditation Board for Engineering Education (JABEE) was created. The JABEE in turn adopted accreditation standards that emphasized "understanding the effects and impact of technology on society and nature, and of engineers' social responsibilities" (Luegenbiehl & Fudano, 2005).

Perspectives from Chile

In another contrast with the situation in the United States, the "Code of Professional Ethics of the Engineers of the Colegio de Ingenieros de Chile [Association of Engineers of Chile]" actually has the force of law, having been formulated in response to general legislation calling for such codes in all professional organizations. Although the Colegio was founded in 1958, this code was, somewhat ironically, not formulated until it was required by the authoritarian regime of Augusto Pinochette in the early 1980s.

The Chilean code, like many codes in developing countries, includes little by way of positive guidance. There is, for instance, no mention of any responsibility to public safety, health, and welfare. Instead, the code consists primarily of an extended list of actions that are contrary to sound professional conduct, and that are thus punishable by professional censure. Among many unremarkable canons against conflict of interest, graft, etc., however, is one rejecting "actions or failures to act that favor or permit the unnecessary use of foreign engineering for objectives and work for which Chilean engineering is sufficient and adequate." This emphasis on national interests can also be found suggested by other codes in developing countries throughout Asia and Latin America. For example, the India Society of Engineers (founded 1934) code of ethics (undated) requires that members "always confirm the National interest"; the Colegio de Ingenieros de Venezuela (founded 1861) code of ethics (promulgated 1988) makes it "contrary to ethics ... to act in any way that would permit or facilitate contracting with foreign companies for studies or projects, construction or inspection of works, when in the judgment of the Colegio de Ingenieros there exists in Venezuela the capacity to perform these tasks."[31]

It is important to note that such an ethical interest need not have simply nationalistic implications. Judith Sutz, for example, a computer scientist in Uruguay, in an essay raising important questions about the directions of information technology research in Latin America, argues that:

The basic question is, what do Latin American engineers want? Do they want to seek original solutions to indigenous problems? Or do they only want to identify with that which is more modern, more sophisticated, more powerful—disregarding

real usefulness—in order to feel like they "live" in the developed world?[32]

Many countries experience a serious difficulty in addressing their own real problems. Driven by what René Girard (1965) calls mimetic desire, engineers and scientists often devote themselves to high-tech research and advanced engineering projects that bring international prestige while sacrificing less glamorous but more useful tasks.

Perspectives from Transnational Engineering Associations

In promulgating its professional code the Colegio of Chile published a pamphlet that included the Code of Professional Ethics of the Latin American Unión Panaméricana de Asociaciones de Ingenieros (UPADI or Pan American Union of Associations of Engineers, established 1949). Two other transnational codes are those of the Fédération Européenne d'Associations Nationales d'Ingénieurs (FEANI or European Federation of National Engineering Associations, founded 1951) and the World Federation of Engineering Organizations (WFEO, founded 1968). Additionally, the national engineering academies of China, Japan, and Korea have formulated a joint "Declaration on Engineering Ethics" (2004) which includes an "Asian Engineers' Guidelines of Ethics." Appropriately enough, all of these transnational documents stress the public good or social responsibility, protection of the environment, and from the perspective of globalization raise issues of social justice.

Duties to Avoid Harm Versus to Do Good, and Social Justice

Through this cultural geography of issues runs an ethical question concerning the relative weights that can be assigned to not acting versus to acting, to duties to avoid harm and to do good. Traditional moral theory distinguishes between harm directly caused by some action and harm that merely follows a failure to act. There are substantive moral differences between an agent who actively kills someone and an agent who stands by while a person dies—especially as distance between the two individuals increases. The difference becomes more pronounced when action carries with it a cost or risk to the intervening agent. It becomes less pronounced as the distance between individuals decreases (as in a family), cost to the agent declines, or professional role responsibilities come into play.

As a result, moral laws of many types (from the Ten Commandments to professional ethics codes) tend to emphasize deontological proscriptions against doing harming (murder, theft, etc.) rather than prescriptions to do good (protecting the public, safety, health, and welfare). Moral standards generally obligate people not to commit (that is, to omit) murder, and call for punishment of agents who do commit harms. Only under special circumstances are people to commit an actthat is, to act to save the life of someone who would die or be harmed without their assistance. Moral ideals may strongly encourage such action but generally do not require it. There is a difference between vice (to be punished), virtue (to be expected), and heroic virtue (to be rewarded). Indeed, to command or to enforce exceptional goodness is characteristic of utopian programs that can produce social orders worse than those they sought to improve. The perfect really can be the enemy of the good.

Issues here are, however, complex. One set of exceptions emerges from professional responsibilities. Physicians have positive obligations to attend to the injured and the ill, even at some cost to themselves. Attorneys have obligations to provide counsel, even to those who may not be able to pay. Such obligations of what might be called regionalized heroism are grounded in the positive ideals of health and justice—combined with a principle of distributive or social justice, which argues that certain goods be made available

at a minimal level to all in a society. Concepts of human rights seek to articulate the type and extent of such goods. But unlike the cases with medicine and law, there is no argument that people have a right to engineering, not even insofar engineering is defined as the art of directing the resources in nature for their use and convenience.

Historically engineering has not been as deeply bound up with principles of distributive justice as have the professions of medicine and law. In philosophy, distributive justice discourse is divided by multiple principles of distribution: from egalitarianism (strict, of opportunity, and cultural) to welfare-based, desert-based, and libertarian. Feminism has developed another distinctive perspective on social justice. Nevertheless, one seldom contested practical application is the common idea of the ill or injured as having a right to basic medical care and of all citizens having a right to legal counsel, so that both physicians and lawyers have a tradition of doing significant pro bono work. But the idea that people might have a "right to engineering" so that engineers would have responsibilities to do some measure of pro bono service is anomolous. Yet the principle of social justice that lies at the foundation of rights to medical care and legal counsel pose ethical challenges to engineers in a world that is becoming progressively engineered. Indeed, as if in response, a kind of social justice engineering is manifested in such organizations as Engineers without Borders and in efforts to move beyond an excessive focus on engineering education that teaches no more than how to design technical solutions to problems.[33]

In light of such distinctions, recall the preliminary contrast between the common ethical issues in science and in engineering—fabrication or falsification of results in science versus defective design and whistle blowing in engineering. A subtle disproportion obtains between the two. With regard to fabrication and falsification in science, there is a secret action that breaks a proscription (do not lie), whereas in whistle blowing a heroic ideal (act to save others harm) has been openly lived up to. The broken proscription in science is likely to have had some immediate personal benefit, whereas the idealistic action in engineering often has personal costs. The moral proscription in science is not to lie—that is, not to perform a certain kind of action that may well cause harm. In engineering, the prescription is to promote safety and to expose threats to it—that is, to perform an action that will produce good. In the case of scientific fraud, public reaction is negative. In the case of engineers who blow the whistle, public reaction is largely supportive. The immediate question, given the distinctions between not causing harm and doing good, is whether it is reasonable for engineers to hold themselves or be held to such a high pro-active ideal.

Consider another possible objection to the engineering ideal. One way of summarizing the distinctions between omission and commission, duties to avoid harm and to do good, is to say that on the traditional interpretation one has an unqualified (deontological) obligation not to harm but only a qualified (consequentialist) obligation to do good. But in many instances this means, in effect, not to act at all—a position that the traditional interpretation finds in harmony with a fundamental belief in the primacy of non-action over action, contemplation over practice.[34]

The problem with such a conclusion in the technoscientific world is two-fold. First, in many cases it seems possible not to cause a certain harm only by acting against a certain good. Had the BART engineers succeeded in requiring more research and testing on the ATC (thus not causing harm) they might have also set the project back further and cost the taxpayers money (causing harm). No clearly positive good would have been obvious, because the non-harm would not have been an event. Second, standing by—certainly within the context of some technical project—only allows the forward momentum of that project to continue unimpeded. The BART engineers were able to stop their previous actions from causing

harm only by doing something to cause a different harm. One response to such dilemma is to attempt an analysis of trade-offs between goods and harms, but the harms easily tend to be more obvious than the goods.

The turn to a consequentialist or utilitarian calculus of trade-offs is also in greater harmony with what may be described as an almost unqualified commitment to practice, to action, to doing something—to commission rather than to omission—that is characteristic of the distinctly modern way of being in the world.[35] Engineers, like most of us who participate in technoscientific modernity, find it difficult under all circumstances to stand by and not to act. It is this commitment and experience, nevertheless coupled with uneasiness about a calculus of trade-offs, that has provoked engineers such a Victor Papanek to propose radical revisions in the engineering profession:

In this age of mass production when everything must be planned and designed, design has become the most powerful tool with which [human beings shape] tools and environments (and, by extension, society and [themselves]). … As long as design concerns itself with confecting trivial "toys for adults," killing machines with gleaming tailfins, and "sexed-up" shrouds for typewriters, toasters, telephones, and computers, it has lost all reason to exist. … Design must become an innovative, highly creative, cross-disciplinary tool responsive to … true [human] needs. … It must be more research oriented, and we must stop defiling the earth itself with poorly designed objects and structures.[36]

4. THE PERSPECTIVE OF DESIGN RESEARCH

The problems of ethical (as opposed to technical) trade-offs as well as other issues in engineering ethics are not equally applicable to the practice of engineering research, design, construction, and operation. It is thus useful to consider the relevance of ethics in what may be thought of as the most refined or abstract form of engineering, that is engineering science research. In engineering research (as in scientific research), issues of obedience, efficiency, public responsibility, and participation are often replaced with a single imperative: Sapere aude! Dare to know![37] Indeed, this is probably something that makes research—including engineering science research—attractive: it avoids moral dilemmas. It is "only" research.

But the term "research" can have weaker and stronger meanings. It can refer (a) to that aspect of the investigation of a problem which plays a continuing subsidiary role in any project, (b) to the initial conceptualization and planning out of a project, or (c) to that specialized activity which constitutes the systematic deepening and elaboration of the engineering sciences. In either of the second two stronger senses, engineering research is only a small but crucial aspect of engineering.[38]

It is worth noting that the very term "research" is distinctly modern, derived by way of the French rechercher (re-, intensifying prefix + chercher, to seek for) from the late Latin recercare. There are no classical Latin or Greek forms of the word. The "intensive searching" that implies an active or "pushy" inquiry can be contrasted with the more leisured and detached, observational study exhibited by pre-modern learning. Indeed, the term first becomes prominent in English during the 1600s in conjunction with the rise of modern experimental science. But not until the early 1900s does it become associated with engineering to designate work directed "in an industrial context" toward "the innovation, introduction, and improvement of products and processes."[39] Research directly for making or building is almost three hundred years younger than research for knowing.

From Research to Design

From the perspective of engineering research in the intense sense, codes of professional ethics appear singularly weak if not irrelevant, precisely

because codes focus on what most engineers do, which is primarily not research. Unlike science, where research is the core activity, engineering research occurs at one end of a spectrum of activities ranging from research and development through construction or production to operation, management, and maintenance. Only a small proportion of engineers are engaged primarily in research, although a much larger proportion no doubt include research as some limited component of their work. Through what might be called research, for instance, engineers rethink projects as they run up against variances from specifications and other difficulties.

What unifies various engineering activities is not research but design. The research engineer investigates new principles and processes, which a development engineer can utilize for designing the prototype of a new device or process. Prototype design can then be modified by the production engineer so that it is more easily manufactured, while operational and maintenance engineers add inputs from the perspectives of their engagements. But the central activity is that of designing, which must take into account production, marketing, maintenance, and use, and is in turn taken into account by research. Engineering research exists to contribute not to knowledge per se but to the design activity, that is, to "the creation of systems, devices, and processes useful to, and sought by, society."[40]

Design and Research

The exact character of this design activity has been variously debated. For present purposes, it is not necessary to explore all aspects; it is sufficient simply to note that design involves a kind of making, or making in miniature[41]—and as such has immediate impact on the world, however small that impact might be. Science may plausibly claim that the outcome of its central activity, research, is a non-physical reality, namely knowledge, which can only have an indirect or mediated impact on the world. By contrast, the outcome of engineering design is a physical object that, however refined, perforce becomes part of the physical world. If it is successful, it may even become a very big part of the physical world.

What is distinctive about research qua research is what has already been referred to as its pushy character, its determination to discover and apply "new facts, techniques, and natural laws."[42] The application of techniques in engineering is further motivated by a "creative imagination" that "is always dissatisfied with present methods and equipment," thus ever seeking "newer, cheaper, better means of using natural sources of energy and materials to improve the standard of living and diminish toil."[43] This uneasiness or restlessness in engineering imparts to and picks up from research a profoundly active character—so that engineering based on or utilizing research is more restless than engineering otherwise. Research oriented toward more effective foundations and support for design, both takes on and transmits engineering restlessness more effectively and powerfully into world-transforming projects. Whereas science could be said to take the world into the laboratory, engineering research takes the laboratory into the world—indeed, eventually makes of the world itself a laboratory.

The method of "testing to destruction," in which materials, devices, or processes are intentionally loaded or operated until they fail in order to discover their limits, is in this sense a particularly revealing form of engineering research.[44] Testing to destruction may be instructively compared, for instance, with the systematic observation of biological fieldwork—and even with the controlled measurement of isolated events under varied conditions in physics. Even in the latter case, where scientific experiment constrains nature in order to confirm a hypothesis, there is, as with Galileo's inclined planes, more the altering for effective observation of a motion that naturally occurs of its own, without any explicit intent to

destroy. With engineering testing, by contrast, a qualitatively new motion is initiated and examined.

The External Impact of Engineering Design Research

Testing to destruction is closely related to traditional cut-and-try methods of construction; the difference is that with testing to destruction such methods are developed and pursued systematically. Moreover, with such systematic development testing to destruction readily leaves the engineering laboratory and becomes part of general engineering practice. This is the upshot of civil engineer Henry Petroski's book, *To Engineer Is Human* (1985). According to Petroski:

the concept of failure—mechanical and structural failure in [this book]—is central to understanding engineering. … [Although] colossal disasters … are ultimately failures of design, … the lessons learned from those disasters can do more to advance engineering knowledge than all the successful machines and structures in the world. Indeed, failures appear to be inevitable in the wake of prolonged success, which encourages lower margins of safety. Failures in turn lead to greater safety margins and, hence, new periods of success. To understand what engineering is and what engineers do is to understand how failures can happen and how they can contribute more than successes to advance technology.[45]

It is precisely because such public testing or using to failure is a normal part of the engineering–society interaction, that philosopher and engineer Martin and Schinzinger (1989) argue for conceiving engineering as "social experimentation." According to Martin and Schinzinger (1989), although experimentation is crucial to engineering, what is involved is not … an experiment conducted solely in a laboratory under controlled conditions. Rather, it is an experiment on a social scale involving human subjects. This is a notion that can also be found in a different context in the arguments of Karl Popper for what he calls "social engineering."[46] It is what justifies Martin and Schinzinger's application of the model of bioethics experimentation with human participants to engineering practice.

It is precisely this turning of the world into a laboratory, which results from engineering design research extending itself through engineering practice, that is the foundation of those unique ethical challenges that have been identified by numerous authors as the special burden of technological society. According to German philosopher Hans Lenk, a member of the VDI *Mensch und Technik* commission, the expanding impact of modern engineering design research can be summarized as follows. In contrast to pre-modern technics, modern engineering now influences (1) more people, (2) more natural systems, and (3) more future generations than ever before. Moreover, not only have (4) human beings become research subjects, so has their (5) genetic structure and (6) behavior, with (7) personal privacy also increasingly at risk. Finally, engineering design research (8) introduces a new dynamism into all human action by investing more and more of its dimensions with that restlessness that is the hallmark of engineering.[47]

In short, as a result of engineering research, the practice of engineering now has an impact across space and through time greater than any other human action. It also extends more deeply into human nature, both physiologically and psychologically, than any previous human action. Finally, the opening of such technical possibilities through engineering design research tends to draw human action into its vortex. As the atomic scientist J. Robert Oppenheimer remarked about Edward Teller's design for a hydrogen bomb, the possibility was so "technically sweet" it could not fail to be tried.[48] The question of the wisdom of engaging in such restlessness must be an ultimate issue of the ethics of engineering.

The Internal Character of Engineering Design Research

This "external" feature of engineering design research is complemented by its "internal" feature of modeling. Modeling is not only a miniature making but also an idealization—or, more accurately, a simplification. The idealization of engineering modeling has a paradoxical character. On the one side, because it is simplification oriented toward making, it is not particularly concerned with truth. Less than fully true models, although conceptually shallow, can be technologically powerful or rich.[49] But what engineering design research modeling thus explicitly gives up in concern for truth it implicitly takes on in concern for ethics. On the other side, precisely because of the simplifications of engineering research modeling, ethical reflection becomes especially difficult.

Engineering design research models the world by simplifying it, by focusing on only one aspect of what is. Free-body diagrams, for instance, treat an object as if all forces were acting directly on its center of gravity, in order to model matter–force interactions. But this "as if" denotes also something that is not. The simplified model is not the complex reality. All forces do not act on the center of gravity of some object; many act on its surface, which, given certain shapes, may distort the result. But only subtly. To concentrate on gross problems it is not only permissible to ignore complex subtleties, but better.

The paradox is that precisely from not reflecting the complexity of reality comes power to change what is into something that is not yet. The Euclidean model of the landscape as a flat surface enables it to be divided up and parceled out, the monetary "disembedding" of the value of goods and services facilitates their economic exchange (Polanyi, 1944). The insertion of such modeling into technical action planning and its extension through systematic research is what gives to modern engineering design its special power.

The modeling of terrestrial gravity, for instance, as independent of the sun, moon, planets, and all variations in geology or physical geography makes possible the calculation of the trajectories of military projectiles. The carefully defined boundary conditions within which the mechanical engineer determines efficiency—taking into account only mechanical energy and heat, but not social dislocation or pollution or biological destruction—is what makes possible improvements in the strictly mechanical functioning of engines.

More generally, looking at the world as a whole as if it were a clock, or the brain as if it were a computer, brings with it tremendous power to transform the thing modeled precisely by overlooking the rich complexity of its reality, by abstracting from the life world within which we actually live (Husserl, 1970). It is thus no accident that given its inner demands for idealization, engineers should on occasion abstract from and refuse to consider one of the most subtle dimensions of the life world—that is, ethics.

Ethics in Engineering Design: The Danger of Idealization

With the overlooking of many aspects of reality that is an essential inner feature of engineering research and design comes not only power but also danger—the danger of overlooking something important. Indeed, it can be argued that precisely what failure points up is that something has been overlooked. But failures are not only technical, they can also be social—and more.

Yet as ideal simplification is an essential inner methodological feature of engineering design research, and there will always be occasions when it is not possible to anticipate what particular idealization parameters are fully appropriate, important aspects of things can regularly be expected to be overlooked—thus creating failures. Precisely because failures, like successes, can be expected outcomes of the modeling inherent in engineering

design research, such research has also developed counter or compensatory principles.

When dealing with progressively more complex projects, engineering research attempts to develop more complex models. Inherent within engineering design research is not only a movement toward simplification, but also a counter movement toward "complexification." Systems engineering, interdisciplinary engineering research, the transformation of civil into environmental engineering, and multi-factor technology assessments all illustrate this latter tendency.

In the BART case, for instance, Hjortsvang argued for a more complex testing of the ATC system. His concern was that the piecemeal testing being done was not able to reveal the full potential for problems, and that the isolated solving of problems that were revealed did not adequately consider the ways such solutions might interact under real world conditions to render the system dysfunctional.

The fact that functional failure might then also harm users can be interpreted as a secondary or supplementary issue. Even without such potential harm, piecemeal testing that does not reveal all real design problems is bad engineering. Hjortsvang thus argued for establishing an interdisciplinary research team to oversee ATC design and development.

The problem that Hjortsvang pointed to is another instance of a problem which, in another situation, has been called "the paradox of information technology." Beyond a certain point human beings "will never be able to model (and thereby check)" in all relevant ways (particularly speed and complexity) data processing operations. Indeed, "the possibility of controlling information processing systems diminishes in proportion to the introduction of modelling or checking instances" as these actually further complicate a program (Zimmerli, 1986, p. 296).

From this example, a general modeling paradox may be stated as follows: The utilization of a simplifying model in a technical design process also complicates the process, as it introduces a new factor to be considered, namely the relation between the model and the phenomenon modeled. And to attempt to model this new relationship will only further complicate the situation. More simply put: There is no way to test a model by modeling it. One can only attend to the modeled (real world) phenomenon, attempt as carefully as possible to take into account all relevant factors, and then pay attention to see if in reality things work the way the model has indicated they will.

In the early 1990s the NAE held a symposium on "Engineering as a Social Enterprise," arguing the need for a sociotechnical systems interpretation of the profession. As symposium organizer, aeronautical engineer Walter Vincenti pointed out how engineers regularly have to deal with technical systems, and are thus familiar with how such systems must be subdivided for analysis. "In the sociotechnical model, the entire society is visualized," according to Vincenti (1991), "as a vast integrated system, with varied social and technical areas of human activity as major interacting subsystems." And although "this subdivision is made so that each subsystem can be analyzed in quasi isolation … analysis must be carried out … —and this is the crucial point—with attention at all times to the interactions between and constraints on the subsystems and to the eventual need to reassemble the system" (p.2). Only such a broad attempt to take everything into account can address any problems raised by any unexpected weaknesses in engineering simplification.

A Duty *Plus Respicere* to Take More into Account

Although implicit in interdisciplinary engineering design practice, environmental engineering, and approaches that envision engineering as part of larger sociotechnical systems,[50] the principle involved here is seldom formulated as such, and thus deserves explicit articulation. Its justification can also be extended from the technical to

the ethical. From the perspective of engineering research and design, the fundamental imperative in the face of failure amid complexity can be phrased as: "Take more factors into account." Without an attempt to follow this imperative, the persistence of failures will indeed become "normal accidents" (Perrow, 1984).

The obligation to take more into account, as a general counterbalance to model simplification, has a moral dimension, not just because it can occasionally avoid some specific harm. As pointed out in relation to the BART case, more complex testing could also cause harm (e.g., greater financial costs). The moral dimension of taking more into account is realized when it links engineering design research into more general considerations of and reflections on the good. In this sense the duty to take more into account may be termed a duty plus respicere (from the Latin plus, more, and respicere, to be concerned about).[51] Indeed, this might also be argued to be an engineering equivalent of the motto: "Think globally, act locally."[52]

The character of ethics as critical reflection on morals has been widely debated in ways unnecessary to rehearse here. Suffice it to note that when ethical reflection argues for the superiority of one moral behavior or belief over another the claim is often made that the superior morality takes more into account than the inferior one. One argument for altruism as superior to selfishness is that it involves a broader perspective, takes more into account, others as well as oneself. In the historico-philosophical development of ethics codes in professional engineering, one defense of the moral superiority of attending to the public good is that doing so entails more generous or inclusive reflection, even and including company loyalty and technical efficiency, which are then placed within a more expansive framework. The arguments of Sutz and Papanek likewise can be construed as attempts to expand the overly simplified modeling that has been characteristic of engineering in both developing and highly developed countries.

Stating the issue even more pointedly: To take more into account in engineering will include taking ethics into account. The problem of the remoteness and subtlety of ethical factors in engineering research and design is obvious. Indeed, this itself might even be said to constitute a distinct ethical problem. Thus, an imperative to seek to reduce such remoteness becomes part of the duty *plus respicere*.

To repeat: Civil engineer George Bugliarello has argued that the social responsibility of the engineer should include upholding human dignity, avoiding dangerous or uncontrolled side effects, making provisions for possible technological failures, avoiding the reinforcing of outworn social systems, and participating in discussions about the "why" of various technologies. For Bugliarello (1991), "engineering can best carry out its social purpose when it is involved in the formulation of the response to a social need, rather than just being called to provide a quick technological fix" (pp.77-81). Such is but another statement of the *plus respicere* imperative.

Practical Guidelines for Exercising a Duty *Plus Respicere*

The proposed duty plus respicere is admittedly a loose and somewhat shapeless deontology. It might even be described as a "soft" ethics, on analogy with soft or alternative technology—perhaps as an example of the poetry that must complement mathematics (Rosen, 1988) or of what has been called "weak thinking" (Vattimo, 1991). But to take this weak ethics a bit further, the following questions could serve as useful guidelines for self-interrogation by research and design engineers.

Applying the basic argument concerning the danger of idealization, a research or design engineer should ask:

- Does the idealization or modeling utilized in this particular design process per chance ignore some factors that, although irrelevant to the boundary conditions of the technical problem, are important to wider concerns?
- Are the models being utilized sufficiently complex to include a diversity of non-standard technical factors?
- Would it be possible to take other factors into account? What might their implications be?
- Does reflective analysis include explicit consideration of ethical issues?
- Beyond such general questions, a research or design engineer might also inquire:
- Has an effort been made to consider the broad social context of the engineering research and design process and its end-use implications, including impact on the environment?
- Have likely end-user assumptions been critically examined?
- Is the research and design process undertaken in dialogue with personal ethical principles and with the larger non-technical community?
- Are there what might appear to be peripheral implications of the research and design process that ought to be given more direct consideration?

In summary, the research scientist should ask: Is this knowledge significant? The research and design engineer should inquire: Is this project worthwhile—and have all relevant factors been taken into account?

5. THE GRAND CHALLENGE OF ENGINEERING ETHICS: A POLITICAL THEORY OF ENGINEERING

But is *plus respicere* enough? How is an engineer to determine what deserves to be taken into account?

The history of engineering ethics in the United States along with key influential cases and permutations in other countries, all disclose a persistent effort to identify the distinctive responsibilities of engineers as those who attempt to enroll nature in the pursuit of human use and convenience—and in the process highlight difficulties of remaining restricted to the framework of ethics. Three cogent cases in point:

- The technocracy movement explicitly sought to give engineers a leadership role in political affairs.
- The ideal of protecting public safety, health, welfare, depends on some measure of engagement with the public itself.
- Efforts to acknowledge responsibilities for the environment typically appeal to the notion of sustainable development, a manifestly political concept.

Use and convenience, like many ethical ideals, call for interpretation. Ethics in the absence of politics remains abstract rationalizing or vacuous romanticism.

Efforts to move beyond ethics to politics have not been wholly absent in American engineering ethics discourse. In response to persistent economic, managerial, or political pressures to compromise technical standards in ways that demand whistle blowing on the part of engineers who would hold paramount public safety, health, and welfare, a number of scholars have sought to consider some aspect of the broader socio-political context in which individual engineers work. Engineer–philosopher Joseph Herkert summarized such efforts using a distinction between

micro-ethics (dealing with relationships individual engineers have with each other, their employers, and clients) and macro-ethics (addressing issues of collective social responsibility of the engineering profession as a whole).[53] Herkert compares the efforts of two philosophers - Ladd & Richard DeGeorge (DeGeorge, 1981), two engineers - George McClean & Willem Vanderberg[54], and an STS scholar - Richard Devon (1999) to conceptualize the macro-ethical context and argues that none successfully integrates the micro- and macro-ethical perspectives. Herkert's own proposal was simply for more research on the responsibilities of professional societies as a whole; specific suggestions are the need for professional engineering societies to establish institutional supports for individual whistle blowers (a proposal advanced in the 1980s by Unger) and to develop statements on public policy issues such as product liability.

Although important, Herkert's discussion manifests a thin view of the political. It makes only the most limited reference to the ways in which engineering transforms the political, as articulated by Langdon Winner,[55] or engages with the political through various forms of technocracy. Related efforts to conceptualize engineering in its broad social and political context can be found in work on science, technology, and society (STS) studies and engineering ethics,[56] humanitarian engineering (Mitcham & Muñoz, 2010), and engineering and social justice. But the grand challenge of moving from ethics to politics remains.

Ethics aspires to provide guidance for individual conduct. Engineering ethics thus aspires to provide guidelines for the behavior of individual engineers. But given the large-scale implications of engineering action, such guidelines have increasingly pointed toward responsibilities that are difficult for individuals to meet without practicing heroic virtue. A duty *plus respicere* to practice public participation, public disclosure, and to do good is at once required and impossible at the individual level. What is called for instead is a political theory of engineering.

Once critical reflection that begins by focusing on guidelines for the behavior of individual engineers recognizes the limitations of such reflection, it readily follows a path mapped classically by Aristotle, whose discussion of ethical theory is explicitly presented as preparatory to political theory. At the conclusion of the *Nicomachean Ethics* Aristotle asks whether it is sufficient to have identified the good and argues that it is not. "With regard to human perfection, knowing is not enough, but we must try to possess it and to put it into practice."[57] Moreover, as the practice of human perfection is in many instances dependent not simply on reason but also on the political order in which a person lives, "the constitution of the state must be considered in order to complete the ethical examination of human nature."[58] What for Aristotle was the case with regard to basic-level virtue would seem to be even more strongly required when virtue takes on a supererogatory character.

In 2003, the U.S. National Academy of Engineering took the turn of the century as an opportunity to look back and identify the 20 Greatest Engineering Achievements of the 20th century. These non-rank ordered achievements—which ran from urban water systems to the development and distribution of electricity and the inventions of automobiles, airplanes, radio, movies, television, nuclear power, spacecraft, computers, lasers, and the internet—have, according to the NAE, "revolutionized and improved virtually every aspect of human life."[59] In effect, this constituted a backward looking interpretation of the engineering ideal of use and convenience.

Five years later, in order to craft a forward-looking interpretation of use and convenience, the NAE formulated fourteen "Grand Challenges for Engineering in the 21st Century."[60] These challenges were grouped into four themes described as "essential for humanity to flourish": sustainability, health, reducing vulnerability, and joy of living. It was explicitly stated that the selection committee of 18 engineers, scientists, and entrepreneurs did

not mean to list every single important challenge; neither did it endorse all particular proposals for addressing the four themes. Instead, "the goal was to identify what needs to be done to help people and the planet thrive."

As a result of NAE promotion, the grand challenges rhetoric has become a standard approach to the understanding of engineering. What is seldom noticed, however, is the extent to which this rhetoric replays the military origins of engineering in the West. The idea of linking applied science and engineering to societal benefit by specifying grand challenges goes back to an initiative from the Defense Advanced Research Projects Agency (DARPA). In the 1980s, in response to the perceived threat of the Japanese project to create a "Fifth Generation" of computers, the science adviser to President Ronald Reagan defined a "grand challenge" as "a fundamental problem in science or engineering, with broad applications, ... that could become available in the near future,"[61] which was then given to DARPA. In the 2003–2005 timeframe this concept was picked up by a militant non-governmental organization, the Bill and Melinda Gates Foundation, when it formulated a set of 16 "Grand Challenges in Global Health" that ranged from vaccines that do not require refrigeration to biomarkers of health and disease.

Since 2008 grand challenges thinking has become a growth industry—and a form of political discourse. The grand challenges for engineering are meant not just as statements for engineers but also for non-engineers: to recruit students to engineering (see the Grand Challenges Scholars Program[62]) and to promote broad public support for engineering. The grand challenges constitute more than an engineering ethics; they seek to argue for a particular place of engineering in human affairs and the political order. They constitute an implicit political theory of engineering—a theory that deserves to be more consciously and critically considered. The true grand challenge for engineering is engineering ethics and a political philosophy of engineering.

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KEY TERMS AND DEFINITIONS

Duty *Plus Respicare***:** An obligation to take more things into account in engineering ethical decision making. The Latin *plus respicare* is an artificial coinage meaning "to look more". The chapter argues that, given the increasing importance and power of engineering, engineers must expand their moral horizons.

Grand Challenges for Engineering: In 2008 a U.S. National Academy of Engineering report identified 14 non-rank ordered grand challenges by which engineering could contribute to improving the quality of life in the 21st century. These challenges range from making solar energy economical to reverse engineering the brain and encapsulate a vision of the relationship between engineering and society.

Participation Principle: During the last third of the 20th century it became increasingly common to argue that because of the risks associated with many technological changes it was important to establish processes for the affected publics to

have a say in the decisions regarding engineering projects. The chapter adopts the shorthand "participation principle" to refer to this proposal.

Public Safety, Health, and Welfare: Since the middle of the 20th century, professional engineering societies have adopted codes of ethics that make protecting public safety, health, and welfare a primary moral responsibility for engineers. Although this formulation of professional engineering ethics originated in the United States, it has been widely adopted by professional engineers throughout the world.

Technocracy: "Technocracy" is a term that implies some type of rule by technical elites, whether engineers or scientists. Such rule can be direct (engineers holding executive or legislative office) or indirect (political decisions being made on the basis of advice from engineers). Technocracy exists in tension with ideal of democracy.

ENDNOTES

1 The quotation or some form of it is all over the Internet but never sourced. A similar unsourced statement ("Scientists investigate that which already is; engineers create that which has never been") is often attributed to Albert Einstein. Retrieved June 12, 2014, from http://www.nmspacemuseum.org/halloffame/detail.php?id=31

2 See, e.g., Kármán, T. (1956). *Collected works.* Vol. IV 1940-1951. London: Butterworths Scientific Publications. Please refer to "Some Remarks on Mathematics from the Engineer's Viewpoint" (pp. 1-6), "Tooling Up Mathematics for Engineering" (pp. 189-192), and "Atomic Engineering? (pp. 252-254).

3 The first ethics codes are not formulated in scientific societies until the last half of the 20th century, whereas they began to be discussed in engineering at the end of the 19th century. Compare, for instance, information about the development of ethics codes in the early 1900s in Edwin T. Layton, Revolt of the Engineers: Social Responsibility and the American Engineering Profession (Cleveland, OH: Press of Case Western Reserve University, 1971) with the account of the 1960s discussions of ethics in the AAAS in Dale Wolfle's Renewing a Scientific Society: The American Association for the Advancement of Science from World War II to 1970 (Washington, DC: American Association for the Advancement of Science, 1989).

4 Derived from Tredgold, T. (1828). Description of a civil engineer. *Institution of Civil Engineers, Meeting of Council*, pp. 20-23.

5 See David Hume (1751). *Enquiry concerning the principles of morals*. Section II, part II, paragraph 5. Cf. A Treatise of Human Nature (1738), III, part III, section I, paragraph 8. For philosophical criticism that can apply to this concept, see Albert Borgmann, Technology and the Character of Contemporary Life: A Philosophical Inquiry (Chicago: University of Chicago Press, 1984); and Thomas F. Tierney, The Value of Convenience: A Genealogy of Technical Culture (Troy, NY State University of New York Press, 1993)

6 Tocqueville, A. (1835). *Democracy in America*, vol. I, chapter 12.

7 For sociologists ''structural differentiation'' describes how modern social orders are characterized by separations among, for example, the religious, political, and economic institutions in ways not typical of premodern societies. Among those who have developed the concept of structural differentiation most fully are Talcott Parsons and his student Neil Smelser; see, e.g., Smelser, Social Change in the Industrial Revolution: An Application of Theory to the British Cotton Industry, 1770–1840 (Chicago: University of Chicago Press, 1959).

8 Charles P. Steinmetz, Harold W. Buck, and Schuyler Skaats Wheeler, ''Proposed Code

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9 Charles Whiting Baker, Charles T. Main, E. D. Meier, Spencer Miller, and C. R. Richards, Committee on Code of Ethics, ''A Proposed Code of Ethics for Engineers,'' Engineering News: A Journal of Civil, Mechanical, Mining and Electrical Engineering, vol. 69 (1913), p. 29.

10 See Marcia Baron, The Moral Status of Loyalty (Dubuque, IW: Kendall/Hunt, 1984).

11 Thorstein Veblen, The Engineers and the Price System (New York: Viking Press, 1921). For general background, see Layton, The Revolt of the Engineers. For more particular study, see William E. Akin, Technocracy and the American Dream: The Technocrat Movement, 1900-1941 (Berkeley: University of California Press, 1977).

12 Matthew Wisnioski's Engineers for Change: Competing Visions of Technology in 1960s America (Cambridge, MA: MIT Press, 2012) offers an excellent narrative analysis of this period in American engineering history.

13 P. Aarne Vesilind and Alastair S. Gunn, Engineering, Ethics, and the Environment (Cambridge, UK: Cambridge University Press, 1998). See especially chapters 3, "The Search for Environmental Ethics in Professional Codes of Ethics." An earlier version of this book was published as Gunn and Vesilind, Environmental Ethics for Engineers (Chelsea, MI: Lewis Publishers, 1986). N.B. There is a problem with the Vesilind and Gunn account of ASCE recognition of environmental responsibility. According to Vesilind and Gunn, in 1975 the ASCE code simply adopted verbatim the Fundamental Principles from the ABET model code. There are three problems here: (1) According to ASCE itself, the new code was adopted in 1977. (2) Although the ASCE code states, like Vesilind and Gunn, that it adopts the principles from ABET, ECPD did not become ABET until 1980. (3) The first principle is not in fact the same as the ECPD principle. The ECPD first principle states that engineers will use "their knowledge and skill for the enhancement of human welfare." The ASCE first principle states that they will use "their knowledge and skill for the enhancement of human welfare and the environment."

14 For an argument complementary to Vesilind and Gunn on the emergence of sustainability as a theme in engineering, see Sharon Beder, The New Engineer: Management and Professional Responsibility in a Changing World (South Yarra, Australia: Macmillan, 1998). For analysis of the contested character of the concept of sustainability, see Carl Mitcham, "The Sustainability Question," in Roger S. Gottlieb, ed., The Ecological Community: Environmental Challenges for Philosophy, Politics, and Morality (New York: Routledge, 1997), pp. 359-379. See also ASCE, The Vision for Civil Engineering in 2025 (Reston, VA: ASCE, 2007). In 2009, the ASCE formally defined sustainable development as "the process of applying natural, human, and economic resources to enhanve the safety, welare, and quality of life for all of society whicle maininging the availability of the remaining natural resources."

15 National Academy of Engineering, The Engineer of 2020: Visions of Engineering in the New Century (Washington, DC: National Academies Press, 2004).

16 Mike W. Martin and Roland Schinzinger, Ethics in Engineering (New York: McGraw-Hill, 1983), chapter 3, "Engineering as Social Experimentation." The argument is further developed in subsequent editions of their influential textbook (1989, 1996, and 2005). For another articulation of the analogy, see also K.S. Shrader-Frechette, Risk

and Rationality: Philosophical Foundations for Populist Reforms (Berkeley: University of California Press, 1991), pp. 72-74, 86-87, and 206-214.

17 Langdon Winner, "Artifact/Ideas and Political Culture," Whole Earth Review, no. 73 (Winter 1991), pp. 18-24; and Steven L. Goldman, "No Innovation without Representation: Technological Action in a Democratic Society," in Stephen H. Cutcliffe, Steven L. Goldman, Manuel Medina, and José Sanmartín, eds., New Worlds, New Technologies, New Issues (Bethlehem, PA: Lehigh University Press, 1992), pp. 148-160.

18 For brief review of this discussion, see Mitcham, C. (1997). Justifying public participation in technical decision-making. *IEEE Technology and Society Magazine*, *16*(1), pp. 40-46.

19 Winston Churchill is often quoted as describing the proper role of scientists as being "on tap, but not on top." See Randolph S. Churchill, Twenty-One Years (London: Weidenfeld,1964), p. 127.

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21 For detail on this history, see John G. Burke, "Bursting Boilers and the Federal Power," Technology and Culture, vol. 7, no. 1 (Winter 1966), pp. 1-23. Reprinted in Marcel C. Lafollette and Jeffrey K. Stine, eds., Technology and Choice: Readings from Technology and Culture (Chicago: University of Chicago Press, 1991), pp. 43-65. John K. Ward, "The Future of an Explosion," American Heritage of Invention and Technology, vol. 5, no. 1 (Spring-Summer 1989), pp. 58-63, provides further information on the role played by the insurance companies. Unfortunately Wilbur Cross, The Code: An Authorized History of the ASME Boiler and Pressure Vessel Code (New York: ASME, 1990), is neither well written nor especially informative. For more general analysis of American efforts in the deployment of technical knowledge for the democratic regulation technology, see Sheila Jasanoff, The Fifth Branch: Science Advisers as Policymakers (Cambridge, MA: Harvard University Press, 1990). N.B. The term "science" is often, as here, used to include engineering and technology.

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23 For documentation, see Robert M. Anderson, Robert Perrucci, Dan E. Schendel, and Leon E. Trachtman, Divided Loyalties: Whistle-Blowing at BART (West Lafayette, IN: Purdue University Office of Publications, 1980); and "The BART Case," in Stephen H. Unger, Controlling Technology: Ethics and the Responsible Engineer, 2nd ed. (New York: John Wiley, 1994), pp. 20-27.

24 For documentation, see Roger Boisjoly, "The Challenger Disaster: Moral Responsibility and the Working Engineer," in Deborah Johnson, ed., Ethical Issues in Engineering

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26 This is stated as the "leitmotif" of engineering in the Verein Deutscher Ingenieure pamphlet, VDI: Zukunftige Aufgaben (Düsseldorf: VDI, 1980).

27 A useful introduction to engineering ethics in Germany is Hans Lenk and Günter Ropohl, eds., Technik und Ethik [Technology and ethics] (Stuttgart: Philipp Reclam, 1987), which includes as an appendix (pp. 297-325) the "Verein Deutscher Ingenieure, Ausschuß `Grundlagen der Technikbewertung': Vorentwurf für eine Richtlinie `Empfehlungen zur Technikbewertung'" [Association of German Engineers, "Foundations of Technology Assessment" Committee: Preliminary draft of a "Recommendations for Technology Assessment" guideline], parts 1-3 of five parts. See also Günter Ropohl, Ethik und Technikbewertung [Ethics and technology assessment] (Frankfurt: Suhrkamp, 1996).

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29 The best single source for background on the Deltawerken is the multilingual "Deltawerken online" web site at http://www.deltawerken.com/Nederlands/1.html?setlanguage=nl. This mega-engineering project also pioneered methods of project definition and research, including broad-based risk-cost-benefit analysis, utilizing statistical data on environmental behavior (e.g., designing to withstand a 250 year storm), simulation, and ecological integration. See also Henk L.F Saeijs, Turning The Tide: Essays on Dutch Ways with Water, trans. Paul Karis (Delft, Netherlands: VSSD Delft Academic Press, 2009).

30 For a more full account, see I.R. van de Poel, H. Zandvoort, and M. Brumsen, "Ethics and Engineering Courses at Delft University of Technology: Contents, Educational Setup and Experiences," Science and Engineering

Ethics, vol. 7, no. 2 (2001), pp. 267-282. For general background, see Hub Zwart and Annemiek Nelis, "Dutch Perspectives," in Carl Mitcham, ed., Encyclopedia of Science, Technology, and Ethics (Detroit: Macmillan Reference, 2005), vol. 2, pp. 552-556.

[31] Quoted (with minor corrections) from Appendix V, "Ethics Codes and Related Documents," the collection of "Non-U.S. Engineering Societies," in Carl Mitcham, ed., Encyclopedia of Science, Technology, and Ethics (Detroit: Macmillan Reference, 2005), vol. 4, pp. 2183-2252.

[32] Judith Sutz, "The Social Implications of Information Technologies: A Latin American Perspective," in Carl Mitcham, ed., Philosophy and Technology, vol. 10: Spanish Language Contributions to the Philosophy of Technology (Boston: Kluwer, 1993), pp. 297-308.

[33] For discussion attempting to re-conceive engineering in terms of social justice, see Donna Riley, Engineering and Social Justice (San Rafael, CA: Morgan and Claypool, 2008); Rachelle Hollander and Nathan Kahl, eds., Engineering, Social Justice, and Sustainable Community Development (Washington, DC: National Academy Press, 2010); and Juan Lucena, Engineering Education for Social Justice: Critical Explorations and Opportunities (Dordrecht: Springer, 2013). For further arguments in this rapidly developing area, see the open access International Journal of Engineering, Social Justice, and Peace (vol. 1, 2012-present).

[34] This might also be described as the "technological pacifist" position of Jacques Ellul. See, e.g., Jacques Ellul, "The Search for Ethics in a Technicist Society," Research in Philosophy and Technology, vol. 9 (1989), pp. 23-36.

[35] See Hannah Arendt, The Human Condition (Chicago: University of Chicago Press, 1958), and the analysis of work as the dominant category of modernity.

[36] Victor Papanek, Design for the Real World: Human Ecology and Social Change, 2nd revised edition (New York: Van Nostrand Reinhold, 1984), pp. ix-x. The quotation is actually from a preface to the first edition, 1971. Much the same thesis is repeated in Victor Papanek, The Green Imperative: Natural Design for the Real World (New York: Thames and Hudson, 1995).

[37] Immanuel Kant, "What Is Enlightenment?" trans. Lewis White Beck, in Immanuel Kant, On History (Indianapolis, IN: Bobbs-Merrill, 1963), p. 3.

[38] The term "research" is, for instance, conspicuous by its absence in the article on "Engineering Design" (the main entry on engineering) in the McGraw-Hill Encyclopedia of Science and Technology, 10th edition (New York: McGraw-Hill, 2007), vol. 6, pp. 561-568. "Research engineering" has, however, been given subsidiary mention in some textbook introductions to the profession — see, e.g., Ralph J. Smith, Blaine R. Butler, and Williams K. LeBold, Engineering as a Profession, 4th ed. (New York: McGraw-Hill, 1983); and M. David Burghardt, Introduction to the Engineering Profession (New York: HarperCollins, 1991). Caroline Whitbeck, Ethics in Engineering Practice and Research (Cambridge, UK: Cambridge University Press, 1998), 2nd ed. 2011, is the only engineering ethics text to include a prominent examination of research; see 2nd ed., part III, "Responsible Research Conduct," with chapters on "Ethics in the Changing Domain of Research" and "Responsible Authorship and Credit in Engineering and Scientific Research." As these chapter titles suggest, she nevertheless approaches the topic primarily by extending discussions of ethics in scientific research to engineering research rather than undertaking

to identify what is unique to engineering research as such.

39 Oxford English Dictionary, 2nd edition (1989), vol. 13, p. 692, col. 3, top.

40 "Engineering Design," McGraw-Hill Encyclopedia of Science and Technology, 10th edition (New York: McGraw-Hill, 2007), vol. 6, p. 561.

41 For an argument of this thesis plus relevant discussion of the alluded to debate concerning design, see Carl Mitcham, "Engineering as Productive Activity: Philosophical Remarks," in Paul T. Durbin, ed., Critical Perspectives on Nonacademic Science and Engineering (Bethlehem, PA: Lehigh University Press, 1991), pp. 80-117. Four other relevant references: Louis L. Bucciarelli, Designing Engineers (Cambridge, MA: MIT Press, 1994; Clive L. Dym, Engineering Design: A Synthesis of Views (New York: Cambridge University Press, 1994); Vladimir Hubka and W. Ernst Eder, Design Science: Introduction to the Needs, Scope and Organization of Engineering Design Knowledge (London: Springer, 1996); and G. Pahl and W. Beitz, Engineering Design: A Systematic Approach, trans. Ken Wallace, Luciënne Blessing, and Frank Bauert, ed. Ken Wallace (London: Springer, 1996).

42 "Research," McGraw-Hill Dictionary of Scientific and Technical Terms, 6th edition (New York: McGraw-Hill, 2003), p. 1790.

43 "Engineering," McGraw-Hill Encyclopedia of Science and Technology, 10th edition (New York: McGraw-Hill, 2007), vol. 6, pp. 557-558.

44 Medical research on animals is another form of such intensive technological investigation.

45 Henry Petroski, To Engineering Is Human: The Role of Failure in Successful Design (New York: St. Martin's Press, 1985), p. xii. See also the reiteration and further elaboration of this thesis in Henry Petroski, Design Paradigms: Case Histories of Error and Judgment in Engineering (New York: Cambridge University Press, 1994).

46 Karl Popper, The Open Society and Its Enemies, vol. 1: The Spell of Plato, and vol. 2: The High Tide of Prophecy: Hegel, Marx, and the Aftermath (London: Routledge and Kegan Paul, 1945). Social engineering is first mentioned in vol. 1, chap. 3, sec. 4, but then considered at a number of points, with a distinction finally being drawn between utopian (bad) and piecemeal (good) social engineering.

47 Hans Lenk, "Notes on Extended Responsibility and Increased Technological Power," in Paul T. Durbin and Friedrich Rapp, eds., Philosophy and Technology, Boston Studies in the Philosophy of Science, Vol. 80 (Boston: D. Reidel, 1983), pp. 196-197. See also Hans Jonas, "Technology as a Subject for Ethics," Social Research, vol. 49, no. 4 (Winter 1982), pp. 891-898.

48 In the Matter of J. Robert Oppenheimer: Transcripts of Hearing before Personnel Security Board, Washington, DC, April 12-May 6, 1954 (Washington, DC: U.S. Government Printing Office, 1954), p. 251.

49 Cf. Mario Bunge, Scientific Research II (New York: Springer, 1967), chapter 11, "Action," pp. 123 ff.

50 See, e.g., Bijker, W.E., Hughes, T.P., and Trevor Pinch (Eds.). (1987). *The social construction of technological systems: new directions in the sociology and history of technology.* Cambridge, MA: MIT Press.

51 Note, also, that respicere (a quite common verb meaning to care for, provide for, consider, gaze or at, respect) is composed of re-, intensifying prefix + specere, to look at or behold, the latter of which is related to the Greek σκέπτω (from which is derived the English "skepticism").

52 This slogan, which has become a popular motto of the environmental movement, was apparently coined independently about the

same time by two French social critics. See René Dubos and Jean-Paul Escande, Quest: Reflections on Medicine, Science, and Humanity, trans. Patricia Ranum (New York: Harcourt Brace Jovanovich, 1980 [French original 1979, from interviews recorded in September 1978]), p. 105; and Jacques Ellul, Perspectives on Our Age, ed. Willem H. Vanderburg, trans. Joachim Neugroschel (New York: Seabury, 1981 [from interviews recorded early in 1979]), p. 27.

[53] Joseph R. Herkert, J.R. (2001). Future directions in engineering ethics research: microethics, macroethics, and the role of professional societies. *Science and Engineering Ethics*, *7*(3), pp. 403-414. The micro/macro distinction had been proposed much earlier by John Ladd, "The Quest for a Code of Professional Ethics: An Intellectual and Moral Confusion," in Rosemary A.Chalk, Mark S. Frankel, and Sallie Birket Chafer, eds., AAAS Professional Ethics Project: Professional Ethics Activities in the Scientific and Engineering Societies (Washington, DC: American Association for the Advancement of Science, 1980), pp. 154-159.

[54] McLean, G.F. (1993). Integrating Ethics and Design. *IEEE Technology and Society Magazine*, *12*(3), pp.19-30. Vanderburg, W.H. (1995). Preventive engineering: strategy for dealing with negative social and environmental implications of technology. *Journal of Professional Issues in Engineering Education and Practice*, *121*, pp. 155-160.

[55] See Winner, L. (1977). *Autonomous technology: Technics-out-of-control as a theme in political thought.* Cambridge, MA: MIT Press, and Winner, L. (1986). *The whale and the reactor: A search for limits in an age of high technology.* Chicago: University of Chicago Press.

[56] Johnson, D.G. and Wetmore, J. M. (2008). STS and Ethics: Implications for Engineering Ethics. In Edward J. Hackett, Olga Amsterdamska, Michael E. Lynch, and Judy Wajcman (Eds.). *The handbook of science, and technology studies* (3rd edition). Cambridge, MA: MIT Press. pp. 567-581.

[57] Nicomachean Ethics X, 9; 1179b1-4.

[58] Nicomachean Ethics X, 9; 1181b13-15.

[59] A Century of Innovation: Twenty Engineering Achievements that Transformed our Lives. Washington, DC: The National Academies Press, 2003.

[60] Retrieved July 9, 2014, from http://www.engineeringchallenges.org/cms/8996/9221.aspx.

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Ethics is not Enough

Chapter 6
Emotional Intelligence:
Its Significance and Ethical Implications in Engineering Profession

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ABSTRACT

Engineers are observed as an archetype of people who carry out their professional tasks through rationality and quantitative aptitude. Thus, they do not consider themselves responsible for any sort of consequences their designed products have. But in contrast to their claim, many scholars argue that engineering products cannot be judged as value neutral as they are designed for public use. The product is good when people use it and get benefit from it and bad when tragedy occurs. The tragedy can be abated or possibly avoided if engineers would incorporate Emotional Intelligence (EI) into their professional task. EI is defined as "skills" that subsume self-awareness, self-regulation, motivation, empathy, and social skills. Thus, not incorporating EI in the engineering task brings about unwanted tragedies. Against this backdrop, this chapter critically examines the salient features of EI, three models of EI, significance of integrating EI into engineering design, methods to learn and develop EI, and ethical implications of EI in engineering profession.

INTRODUCTION

Engineering is a profession because of two primal reasons. First, engineers have earned the mastery of a specialized body of knowledge. Second, they use that knowledge to securing or preserving the well-being of others. The engineering profession thus belongs to "professional model," and not to the "business model." The differences between these models are:

a. In the business model, the priority is given to selling products and getting profit from that, whereas in the professional model, priority is given to protect 'rights' of the public, such as, their safety, health, and welfare, along with that getting benefit for selling products to them.
b. Professional model does not allow professionals to take unfair advantage of the public in the name of profit. But in the case of business model, there may be possibilities

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where professionals sell products to the public without informing them merits and lacunas of the products.

c. Professionals practicing engineering, law, accounting, medicine, come under professional model. But sales persons and manufacturers belong to the business model.

Engineers are professionals and have both ethical and technological responsibilities, which is found in their code of ethics. They innovate new technologies and take responsibility for their innovations. To adapt this condition they need to possess multiple skills known as "emotional intelligence (EI) skills." EI skills subsume skills like self-awareness, self-regulation, motivation, empathy, and socialization.

It is observed that engineers at large do their professional tasks based on their rationality and quantitative aptitude. So they don't consider themselves solely responsible for the consequence of their designed artifacts (Coeckelbergh, 2012; Kermisch, 2012; Roeser, 2012 & 2006; Baura, 2006; Sunstein, 2005). The denial of responsibility and the attitude of engineers are not accepted to most of the scholars belonging to Science, Engineering, and Philosophy disciplines. They disagree with this claim and state that engineers are expected to abide their code of ethics and violation of it will hold them responsible, and thereby accountable. They proclaim that if engineers will design the artifacts solely based on their rationality then they won't be able to predict the consequences of the artifacts. So, along with rationality and quantitative aptitude they need to include emotions (e.g. empathy for the people who will bear the impacts of tragedy, concerns for animal deaths, environmental pollution, etc.) in their design process. As a result, they would be able to produce humane technologies and avoid the unwanted tragedies. To do so, they need multiple skills, i.e. EI skills.

EMOTIONAL INTELLIGENCE: A CRITICAL CONCISE REVIEW

The expression "emotional intelligence (EI)" appears to be an oxymoron, but it is not so. It is a cooperative combination of intelligence and emotion (Roberts et al., 2001; Ciarrochi et al., 2000). It is a set of abilities, which corroborate matters of personal and emotional importance to the individuals (Zajonc, 1980). It assists in predicting consequences of events (Mayer, 2000). It is "the ability to perceive emotions, access and generate emotions so as to assist thought, understand emotions and emotional knowledge, and reflectively regulate emotions so as to promote emotional and intellectual growth" ((Mayer & Salovey, 1997, p.5). This definition is acceptable to Riemer (2003), Zeidner et al. (2004), Fernandez-Berrocal et al. (2006), and Angelidis and Ibrahim (2011). Further, EI affects a wide array of work behaviors, including employee commitment, teamwork, development of talent, innovation, quality of service, and customer loyalty (Zeidner et al., 2004, p.386). In Cooper's (1997) findings, it is highlighted that professionals having EI skills achieve career success, develop strong interpersonal relationships, and achieve the goals of their life. EI therefore plays a vital role in engineering, where engineering practice is a profession, to make engineering a success.

According to Goleman (1998), "EI is the sine qua non of leadership" (p. 4). Professionals lacking EI skills can't maintain their self-confidence. Ashkanazy and Daus (2005) state that EI skills are to identify, perceive, understand, and manage emotions in oneself and others. Van Rooy and Viswesvaran (2004) explain EI is "a set of abilities that enable professionals to generate, recognize, express, understand, and evaluate their own and others' emotions in order to guide thinking and action that successfully cope with emotional demands and pressures" (p.72).

IS EMOTIONAL INTELLIGENCE SAME AS INTELLIGENCE QUOTIENT?

Intelligence Quotient (IQ) is a measure of mental ability that concerns the handling of, and reasoning about, information of various sorts (Mayer et al., 2008, p.510; Carroll, 1993). It measures cognitive ability of a person, whereas EI is a blend of cognitive and affective skills of a person. IQ is used in problem-solving tasks, but EI facilitates thinking (Mandler, 1975) and makes professionals better decision-makers (Lyubomirsky et al., 2005). It promotes and encourages the creative works (Amabile et al., 2005). Thus, professionals are expected to acquire EI skills to deal with their professional tasks.

Cooper and Sawaf (1997) in their study found that IQ contributes only 4 percent to professional success, as it does not contribute to our creative thinking. "Intelligence" measured by IQ can fall short without EI (Riemer, 2003, p. 190). EI contributes to identifying the needs of oneself and others. It enhances work skills and fulfills the intellectual accomplishment. According to Segal (1997) an adult's IQ is said to be fairly constant whereas EI can be developed. Gibbs (1995) asserts that IQ gets professionals hired, but EI gets them promoted. EI helps the professionals to attain their goals. Goleman (1998) evokes that EI skills are four times more important than IQ in determining professional success and prestige. Thus EI skills contribute significantly to achieve professional goals, and thereby play a pivotal role in professional success (e.g., engineering achievements).

EI skills don't come to professionals along with their birth; rather it is to be nurtured and stimulated. It can be learnt through conscious choice. EI skills can be achieved through special training (Goleman, 2001, p.214). EI skills help to achieve pre-decided goals at the workplace. Thus it is required for the professionals to acquire these skills before practicing their profession. By implication, engineers as professionals must acquire these skills to some degree to practice engineering.

EI AND ENGINEERING

Researchers have investigated a wide range of issues related to EI, but its significance in the engineering profession has not been explored thoroughly (Riemer, 2003; Jansen, 2002; Goleman, 1995; Culver, 1998). This chapter tries to explore it in detail. EI is considered to be an important quality of professionals (Boyatzis and Saatcioglu, 2008; Bradberry and Greaves, 2005), because it predicts a wide range of additional positive outcomes (Angelidis and Ibrahim, 2011; Goleman et al., 2002; Dulewicz et al., 2005), and enhances the team performance (Jordan and Troth, 2004). Gohm (2003) states that EI skills are related to job satisfaction as they accelerate professionals' abilities to work under high stress. Holt and Jones (2005) evoke that "EI is becoming a vital skill as professionals (e.g., engineers) accomplish their work by collaborating with each other" (p.15). Angelidis and Ibrahim (2011) claim that those who have EI skills try to control their actions in such a manner that at the end, their actions won't harm others. Contrast to this view, those who don't possess EI skills may land up in unwanted situations, for example, a situation that may cause harm to human beings, or environment, or natural inhabitants, etc. (e.g., engineering disasters).

MODELS OF EI

EI skills assist professionals (e.g., engineers) to achieve success at work. It has three models:

a. EI ability model (Mayer and Salovey, 1997; Brackett and Salovey, 2006)
b. Bar-On's emotional-social intelligence model (Bar-On, 1997 & 2006)

c. EI competencies model (Goleman, 2001; Boyatzis, 2006)

Let us discuss these models in brief to see how they differ.

The EI Ability-Based Model

The EI ability model includes the ability to perceive accurately, appraise, and express emotion; the ability to access and/or generate feelings when they facilitate thought; the ability to understand emotion and emotional knowledge; and the ability to regulate emotions to promote emotional and intellectual growth (Mayer & Salovey, 1997, p. 10; Fernandez-Berrocal and Extremera, 2006, p. 8).

This model has four branches.

1. Perceiving EI
2. Using EI
3. Understanding EI
4. Managing EI

Perceiving EI

EI can recognize one's own and others' facial and postural expressions (Scherer et al., 2001). Professionals having these skills will be able to do their tasks proficiently and handle difficult situations that arise in their professional tasks. Empathy is an essential component of this branch of EI. It comprehends others' feelings and re-experiences them on oneself (Salovey & Mayer, 1990, p.194). According to Rogers (1951) empathy may be considered as a prime characteristic of EI behavior as it assists professionals to perform their actions in an altruistic manner. EI skills thus enable professionals to gage accurately the affective responses in others and to choose socially adaptive behaviors in response.

Using EI

EI skills are also used for problem-solving tasks. Upon using these skills, professionals are benefited in the following ways.

a. EI assists to generate better ideas in a complex situation (Isen et al., 1987).
b. It motivates and assists performance at complex intellectual tasks (Showers, 1992).
c. It helps to remember information for a longer period and develop creative thinking (Isen et al., 1987).
d. In reference to engineering design, it produces an alternative design if one design goes wrong due to some reason.

Salovey and Mayer (1990) claim, "Individuals having this branch of EI skills may be more creative and flexible in arriving at possible alternatives to problems. They will be more apt to integrate emotional considerations when choosing among alternatives" (p. 200).

Understanding EI

This ability comprehends and analyzes one's own and others' emotions. For example, how shock can turn into grief, how happiness can result in ecstatic pleasure, etc. It deals with the growth of language and propositional thought (Mayer, Salovey, & Caruso, 2004). In this case, professionals always bother about the consequences of their decisions.

Managing EI

This ability clarifies one's integrity and personality. It primarily focuses on how to achieve the goals, acquire self-knowledge and social awareness (Porrott, 2002). It helps professionals to manage one's own emotions in a complex and delicate situation with regard to professional tasks (Wenzlaff et al., 2002; Larsen, 2000). Therefore, Mayer, Caruson & Salovey (1999) state that EI is

a set of interrelated skills that allows professionals to process emotionally relevant information efficiently and accurately.

Bar-On's Emotional-Social Intelligence Model (Mixed Model)

This model is a little wider in its scope than the "ability based model." In Bar-On's (2006) view, "Emotional-social intelligence is a cross section of interrelated emotional and social competencies, skills and facilitators that determine how effectively we understand and express ourselves, understand others and relate with them, and cope with daily demands" (p.3). This skill is required for engineers as they design the artifacts for human use. While designing the artifacts, therefore, they should include social and emotional aspects of professionalism into the rational intelligence. As a result, they would be able to justify their professionalism and responsibility toward the society.

This model has five branches of ability (Fernandez-Berrocal and Extremera, 2006, p.9). These are:

a. Understanding one's emotional self
b. Understanding others' emotions
c. Adaptability
d. Stress management
e. General mood (Optimistic, happiness, positive emotions, etc.)

This model is popularized as "mixed-model," as it embraces social, emotional, cognitive, and personality dimensions of professionalism (Mayer, Salovey, and Caruso, 2000).

EI Competencies Model (Integrative Model)

This model consists of five skills, proposed by Goleman (1995).

a. Knowing one's emotions
b. Managing emotions
c. Motivating oneself
d. Recognizing emotions in others
e. Handling relationships (Fernandez-Berrocal and Extremera, 2006)

This model predicts the effectiveness and personal outcomes at the workplace and in organizational fields (Goleman, 1998). It addresses skills of the professionals with regard to advantages and disadvantages in their decision-making process, and how to achieve goals while working in a team. According to Goleman (2001), EI skills are the learned abilities that result in outstanding performance at work. It is so because it is a coherent and integrative approach to the relationship between emotions and reasoning.

From these analyzes, it is asserted that professionals (e.g. engineers) having EI skills should be able to express, recognize, and regulate their own emotions as well as those of others. It holds motivating adaptive behaviors in their actions and approaches to professional tasks. In this regard, Salovey and Mayer (1990) state that (high) EI persons do not mindlessly seek pleasure, rather attend to emotion in the path toward growth (p.201). Those who lack EI skills may make many mistakes in their actions, as engineers do in their decision-making process, incorporating only intelligence and excluding emotion. Hence, it is suggested that engineers should perceive their emotions, integrate those in their decision-making process to produce a better and humane technology. EI is therefore an important skill to contribute for the professional and personal success.

EI skills assist professionals to do many activities effectively, efficiently, and responsibly. So, will there be any possibility to develop EI skills? It is suggested that EI skills increase with age and practicing of professional tasks. But these skills can be obtained through special training (Goleman, 2001, p.214). EI skills are to be nurtured and stimulated, as they don't come to professionals along with their birth. It can be learnt through

conscious choice. Professionals having EI skills achieve the predetermined goals at the workplace. Thus it is imperative for professionals to obtain EI skills before practicing their profession. By implication, engineers as professionals must acquire these skills to some degree to practice engineering.

WHAT CAN EI PREDICT?

With reference to engineering practice, EI can predict some aspects of success—whether it is about occupational status or personal achievements. Salovey and Mayer (1990) state that EI skills contribute significantly to the professional tasks, wherein professionals can predict the consequences of their designed products. Kelly and Caplan (1993) claim that EI contributes to success in engineering. While taking decisions on certain situations, engineers can predict a wide range of additional positive outcomes, if they possess EI skills (Angelidis & Ibrahim, 2011).

An engineer with high EI can predict the following with reference to engineering profession:

a. The rational control of designed artifacts (Brackett et al., 2004).
b. Merits and lacunas of a technological design.
c. The sustainability of the technology (Mayer & Cobb, 2000).
d. Whether a technological design requires some further tests to judge its usability, validity, and reliability.
e. The importance of possible outcomes (Mayer et al., 2004).

Gibbs (1995) and Goleman (1998) state that because of these contributions to prediction, EI skills deserve significant attention in the engineering profession.

HANDLING RELATIONSHIPS

According to Zeidner et al. (2004), EI skills enable engineers to communicate their ideas and goals in interesting ways. As a result, their team members are more likely to adapt to the work conditions and contribute to achieve the goals. EI skills are also connected to social skills, which help the team members involved in a task to do it religiously and on time (Sjoberg, 2001). EI enhances one's ability to succeed in coping with environmental demands and pressures (Bar-On, 1997). It assists in differentiating demands of immediate and delayed attention. It contributes in developing the optimistic approach to attain goals and objectives of the project. It helps to minimize the technological risks in case of new technological design. It assists in decision-making behaviors. Last but not least, it arouses motivation and interest in engineers to complete the task on schedule.

Engineers having EI skills will be able to

a. Solve ethical and emotional problems easily.
b. Develop sociability at the workplace.
c. Motivate team members to achieve the goals.
d. Open to criticism.
e. Avoid negative behaviors.
f. Possess positive attitude to accomplish the mission.
g. Develop a quality of respecting others and commanding respect from them.
h. Open to new ideas and developments.

Day and Carroll (2004) in their research findings state that EI skills help in taking decisions in a group task. As engineers often do their tasks in a group, it helps them to take right decisions. Lopes et al. (2006) say that EI skills help professionals to enhance their work performance.

Although these three EI models have relevance to the engineering profession, I find the third model (*Integrative model*) is more suitable for engineers. It is so because it is inclusive in its approach and real in its application. It accommodates

the essence of the first two models as well, which describes how to be a responsible professional while engaging in tasks. It guides engineers to take decisions in engineering design process by incorporating intelligence and emotion into it and, how to accommodate team members' view on a decision-making process. Most importantly, it guides engineers to achieve the predetermined goals on time while working in a team.

IMPACT OF EI SKILLS IN ENGINEERING PROFESSION

Engineering profession requires intellectual accomplishments and social skills that can be enhanced through EI. According to Goleman (1998) the major qualities differentiating successful professionals from unsuccessful ones are the competencies underlying EI. The use of EI skills in engineering thus has considerable impact on engineering profession. It is noticed that engineers having EI skills will be able to do the following:

a. Harness their own emotions in order to solve engineering design problems.
b. Integrate diverse ideas and generate new ideas.
c. Remain focused on their tasks for a longer period and as a result evaluate the tasks from different perspectives.
d. Resolve engineering risky design problems by selecting an alternative available safe technology.
e. Deal with stress at the workplace.
f. Motivate team members of a project.
g. Give priority to their commitments and attain success at their work.

In these ways, EI is more important to engineers, as they possess both moral and technological responsibility toward their profession.

ENGINEERING, RISKS, AND EI

A debate is still on, i.e., whether EI is helpful to make a rational decision with regard to moral acceptability of technological risks. Engineers often define risk as a function of probabilities and unwanted perils. They usually evaluate risk by considering cost–time–benefit analysis. In this process they ignore the ethical aspect of technology, i.e. whether the people subject to the risks have taken the risks voluntarily or not, the distribution of risks and benefits for a population, the availability of alternative technology to a risky technological design, etc. It is suggested that a risk is acceptable with regard to engineering and scientific innovations only when there will be a high probability of success and less effect in contrast to a small probability of success and large effect. In this regard, Roeser (2006) states that "cost–benefit analysis oversimplifies the complexity of issues involved in deciding on what is an acceptable risk" (p.694). Slovic (1999) and Fischhoff et al. (1981) convey that a risk always involves judgments as to what count as an unwanted consequence. Roeser states (2006) that EI skills help to judge the moral acceptability of technological risks. Finucane et al. (2000) suggest that engineers as professionals should imbibe EI skills to make right judgments about risky technology.

Roeser (2006) claims that scientists and engineers consider risks to be a one-dimensional quantitative notion, but indeed it is a multi-dimensional, qualitative notion (p.691). Those who have EI skills can therefore take rational decisions on moral acceptability of risk. Further, decision on risky technology on the basis of EI skills certainly evades subjectivity because it encompasses all the possible cognitive abilities. Moral judgments are truth-apt and they concern objective moral truths (Dancy, 2004, 2000; Jackson, 1998; Smith, 1994). Moral truths do not depend on the existence of general moral principles (Dancy, 2004), as they associate with the utilitarianism approach of decision-making. EI skills in this regard may

help engineers to assess what is a morally acceptable risk. Thus, engineers should use EI skills to judge the risk involved in technological products. Jaeger et al. (2001) highlight the shortcomings of "intelligence" in risk analysis and propose that EI skills are indeed helpful to take most appropriate and non-subjective decisions on acceptability of risky technology. Decisions on risky technology require the knowledge of both "emotion" and "intelligence," which enunciate how it feels to be in a situation where people use the engineering artifacts and face the unwanted perils, how it feels when the environment is polluted due to engineering disasters, how it feels when one loses their family members, etc. These predictable and imaginable situations help engineers to understand the intricacies involved in ethics, such as feeling sympathy, empathy, and compassion for others. EI skills in this way may help engineers to take unbiased decisions on risky technology. Damasio (2003) suggests that we need EI skills, which incorporate emotion in order to obtain a rational decision on moral acceptability of technological risks. Roeser (2006), by highlighting other components of emotion, fear and enthusiasm, states that emotions are helpful in assessing the moral values of risks and benefits of a technology (p.695).

IMPACT OF EI IN RISK ASSESSMENT

Merely possessing "intellect" won't be adequate for engineers to take appropriate and unbiased decisions on risky technology. But along with intellect if they will include "emotion" in their decision-making processes, they will be able to take most appropriate decisions on risky technology. Thus, on the use of EI skills in the engineering task, engineers will be able to derive the following benefits.

a. Engineering works are mostly collaborative works. In this context, engineers can segregate their responsibilities among themselves to design an artifact and thereby everyone knows his/her responsibility and accountability with reference to his/her tasks.
b. EI skills assist engineers to list out a fair distribution of risks and benefits of a designed artifact. This encourages team members of an engineering project to do their tasks more promptly and on time.
c. EI skills also assist in assessing one's own emotion and others' emotions for taking a decision on engineering design. It helps engineers to evaluate their actions by reflecting upon the proposition, "are they going to impose their decisions on possible users of their artifacts?"
d. EI may allow engineers to think up alternative designs of an artifact if the original is found defective in the design process and hence avoid risky technological designs. Further, it encourages them to be socially responsible professionals.
e. EI guides engineers to evaluate their technological products and take decisions on moral acceptability ground. They can compare "high probability of success and low risk design" with "low probability of success and high risk design." As a result, they can take the most appropriate decision on their designed artifact.
f. EI may restrain engineers from taking risk decisions merely based on their enthusiasm about the product. It assists them not to be misguided by their mere feelings about the product while overlooking the risks involved in the product.
g. EI may help the engineers to assess the risks in a more democratic and justifiable manner (Shrader-Frechette, 1991).
h. EI critically evaluates engineers' emotions and rationality on decision procedures and encourages the consideration of ethical perspective about risks.

ENGINEERING DESIGNS AND ENGINEERS' RESPONSIBILITIES

Engineering is the most pervasive profession. It is unique in many ways because engineers involve in the development of transport, communication, weaponry, cooking, space travel, etc. While doing their professional tasks, they accept and hold two chief responsibilities, technological and moral, among others. Understanding their responsibilities on the one hand, and integrating technological innovations into it on the other hand is not an easy task. To equip for this challenge, engineers need EI skills, because they are a blend of emotion and intellect.

Engineers are known for making new artifacts for public use. But their artifacts are not risk free. So, they face two important challenges among others. First, how to take decisions in the design process and second, determining how far those decisions are justifiable on moral and technological grounds. Engineers can't dodge the technological and moral responsibility that is enshrined in their code of ethics. In this context, Solomon (2010) states that "technological risk is a matter of choice, control, and responsibility, and uncertainty and insecurity" (p. viii). Technological responsibility primarily includes designing a better and user-friendly technology and moral responsibility subsumes a risk free, good, and non-harmful technology.

To judge a technological risk from the perspective of moral responsibility presupposes possession of moral knowledge. Moral knowledge includes emotional reflection on a task, inferring the consequences of the engineering artifacts, imagining the lives of people and environmental pollution if an engineering disaster occurs. Roeser (2012) argues that engineers need EI skills to develop the morally responsible technologies. Mere rationality will stand as a setback for engineers' technological achievements as it ignores the emotional aspect of judging a risk technology. Van den Hoven (2007) suggests that engineers should adopt the "value sensitive design" methods to develop new technological artifacts. "Value sensitive design" states that "design teams should include moral values and stakeholder values in an iterative process in the technologies they develop" (Zwart et al., 2006; Friedman, 2004). This method helps engineers to reduce risks of a technological artifact by developing an alternative design. Risks, engineers' responsibilities, and engineering designs are not confined to technical matter alone, rather they encompass the moral aspect as well. To handle moral and technical aspects of the designed artifacts, engineers need to possess EI skills, as it is a blend of emotion and intellect. According to Roeser (2012), when engineers think about new technology and new design, they should include EI skills into their decision-making process, so that they will be able to reduce the risks involved in the technological products. EI skills in this sense are inevitable for engineers who want to make well-grounded judgments about acceptable risks (p.109). Further, engineers should take justice, fairness, and autonomy into account when they assess risky aspects of the technology that they designed.

When engineering tragedies occur, engineers' moral responsibility is at stake. It is so because engineers are professionals and they have social responsibility among others. Social responsibility is protected if they do their professional tasks in consonance with moral principles and guidelines. Morality suggests two responsibilities: backward-looking responsibility and forward-looking responsibility (Nihlen Fahlquist, 2008; Slovic, 2010). The prior one indicates the failed responsibility and the latter one suggests how to take precautionary measures to avoid engineering tragedy with regard to engineering artifacts. One can ascribe failed responsibility to shame, embarrassment, guilt, blame, repentance, etc. and forward-looking responsibility to sympathy, empathy, compassion, benevolence, etc. It is suggested that engineers should learn from the backward responsibility and use the knowledge

to design safe and better technologies for public use. Dancy (2004) states that it is indeed hard for engineers to always learn from past mistakes and use the knowledge for future technological designs. It is so because as time passes, new challenges stand before engineers that may have nothing to do with the past engineering designs. In this case, engineers should develop "context sensitive" insights to assess and reflect upon risky technology. Context sensitive insights require EI (Roeser, 2006a). So engineers are advised to develop EI skills to handle their professional tasks with responsibilities. Roberts (2010) gives a different name to engineers, i.e. virtue-responsible persons. He says, a virtue-responsible person is one who possesses the right emotions, at the right time, in the right circumstances, and to the right degree (p.x). Thus, it may be stated that a virtue-responsible person is aware of his/her responsibilities, knows ethical standards of his/her profession, makes right decisions in a given situation, and is accountable for his/her decisions. With these features, engineers can stand as exemplary professionals for others, because these features transcend their technological responsibility. Engineers being the virtue-responsible professionals should undoubtedly possess EI skills, as they involve in many creative tasks and take decisions on their tasks, and lastly are accountable for their decisions and repercussions of the designed artifacts. Thus, it is asserted that engineers with EI skills will be able to develop humane technologies instead of risky technologies. Angelidis and Ibrahim (2011) state that "engineers are increasingly expected to recognize the importance of their responsibilities towards society and to faithfully adhere to certain ethical standards" (p.115).

Further, it is observed that engineering is a collaborative work. So obtaining consensus among colleagues on an issue is a challenging task. But this challenge can be tackled with EI. EI helps to search and find agreement among disagreements. It teaches how to include moral standards in the decision-making process. In these ways, EI skills help engineers to develop humane technologies for public use.

TECHNOLOGICAL INNOVATIONS AND ETHICAL RESPONSIBILITY: AN ENGINEERING DILEMMA

Engineers often try to innovate. Their innovations can be divided into three categories. First, an artifact is designed that has nothing to do with past technologies. It is treated as a new artifact. Second, new dimensions are added to the existing artifacts where major changes are observed, but certainly it won't be treated as a new product. Third, almost everything remains the same except some seemingly minor modifications that have been made to the artifact.

The risk is not grave in the case of the second and third categories of artifacts. But high risk is involved in the first category of artifacts. Engineers won't be able to predict successfully many of the consequences of the artifacts, unlike the first and second categories. If anything goes wrong with regard to the second and third categories of artifacts, public blame the engineers for their innovations or creative works. It is so because even though they design artifacts with their best skills and intelligence, they are expected to provide safe technology. In this context, we will examine how at once technological innovations and safe technology are possible? Is it not a dilemma?

In engineering innovations, finding an exact and accurate solution to a problem is not a usual phenomenon. Sometimes, there may be many solutions found to a problem and each solution has both merits and shortcomings. So, out of many solutions, which one has to be chosen is a challenging task for engineers. In short, how best engineers can fulfill their responsibilities with regard to the engineering design problems where one problem has many solutions? To me, if engineers are caught with this sort of problem,

they can easily take decisions by conforming to their code of ethics.

Engineers need to focus upon a wide range of issues to foresee the consequences of their designed artifacts, because they delve into the challenging projects and deal with colleagues having different characteristics to achieve the project goals. Even though they show their concern for their artifacts from beginning to end, yet some oversights are unavoidable because of various other factors. In this situation, how should we expect an error-free engineering design from engineers?

Here, redesigning a technological artifact due to some lacunas found in its prior design may certainly reduce disadvantages, but certainly does not add any further error to its safety measures. Engineering profession thus requires both engineering expertise and knowledge of ethics to resolve engineering problems that arise in their professional tasks. Thus, it is asserted that engineers need interdisciplinary skills (i.e., EI skills) to handle their professional responsibilities and to design humane technologies.

Van de Poel (2000) says that "the design process is not a linear process, rather it is iterative" (p.26). So, the task of engineers is to discover what best can be produced for the societal requirements. To produce societal required artifacts, engineers need to possess EI skills because these skills assist them to produce value-sensitive design artifacts. "Value-sensitive design" means a design of technology that accounts for human values (Friedman et al., 2003, p.1). EI skills thus do not only help engineers to deal with their professional tasks but also assist them to produce value-sensitive design artifacts for public use.

Engineering is teamwork. So, it is obvious that there will be multiple ideas to design an artifact. This implies a particular product may have many possible designs. Even if there is only one design to manufacture an artifact, seldom is it observed that engineers working in a team may conceive that design on their own. So, a question arises, how should engineers arrive at a consensus to design an artifact? Bucciarelli (1994) and Lloyd (2000) assert that the design process is a social process where negotiation is inevitable. To obtain an agreement among many views about a design, the most important skill engineers need to acquire is communication and negotiation skill, which are the ingredients of EI skills. From these arguments, it follows that engineers need EI skills to do their professional tasks and achieve goals in their profession.

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KEY TERMS AND DEFINITIONS

Emotional Intelligence: The expression 'emotional intelligence' is familiarized as EI. Salovey & Mayer (1990) said that it is "a skill to monitor one's own and others' emotions, to discriminate among them, and to use the information to guide one's thinking and actions" (p. 189). Later, in the year 1997, Bar-On characterizes EI as "an array of non-cognitive capabilities, competencies, and skills that influence one's ability to succeed in coping with environmental demands and pressures" (p.16).

Engineering Design: Engineers design machines, tools, and other gadgets for public use and their benefit. Often it is observed that engineers design machines or tools due to the societal demands. For example, human beings, some years ago, were searching for a machine which can clean their clothes without much of their intervention and labour. Engineers came out with a gadget called Washing Machine. It may be stated that engineering design is nothing but designs made by engineer(s) through their engineering skills and knowledge.

Engineering Ethics: Engineering ethics….. is the study of moral values, issue, and decisions involved in engineering practice (Schinzinger and Martin, 2000). Harris et al. (1996) viewed that engineering ethics as much a part of what engineers in particularly know as factors of safety, testing procedures, or ways to design for reliability, durability, or economy (p. 93).

Ethics: It deals with human actions. It evaluates human actions as good or bad. It guides and regulates human behavior. It is stated that 'ethics' embraces beliefs and practices about good and evil by which we guide our behavior. It is the reflective consideration of our moral beliefs and practices. It distinguishes human beings from other creatures.

Intelligence Quotient: Intelligent Quotient (IQ) is an ability that comes to individuals along with their birth. It represents one's reasoning ability. IQ of a person decides whether (s)he should do an assigned task or not. It guides individuals to take decisions right away in a given situation/ context.

Professionalism: The term 'profession' is a sociological term. It is so because societies decide which occupations are to be treated as professions and why. In this context, Harris, C. et al. (2003) iterated that an individual is to be treated as a professional if (s)he satisfies the following features: extensive training received to perform the tasks, having vital knowledge and skills on the subject domain, control on the services, enjoying the autonomy in the workplace, and possessing knowledge about the ethical regulations (pp.2-3). Professionalism is a trait of professionals. In David Maister's view, professionalism is believing passionately in what you do, never compromising your standards and values, and caring about your clients, your people and your own career.

Chapter 7
Religious Ethics, General Ethics, and Engineering Ethics: A Reflection

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ABSTRACT

The objective of this chapter is to examine the underpinning relation among religious ethics, general ethics, and engineering ethics. We, the human beings, belong to one religion or the other by birth and/or by practice. There is hardly any society that is non-religious, and every major religion has religion-based ethics. Every evolved religion promotes values such as honesty, truthfulness, nonviolence, helping the needy, etc. These values are developed by major religions, such as Hinduism, Christianity, Islam, Buddhism, Jainism, etc. All these values together constitute our understanding about general ethics. Fortunately, many religions prescribe similar values, and these values are considered as general ethics, which the chapter delineates in detail. The chapter also elucidates why we have not considered agnostics' and atheists' views on religious ethics even if general ethical principles are based on religious ethics. Further, what is the need to have professional ethics such as engineering ethics when we already have religious and general ethics? The chapter argues "engineering ethics" as a professional ethics would be an autonomous system and would be independent of religious ethics and general ethics. The reason for this claim is professionals need to perform their duties in accordance with their professional codes of conduct, and not based on their religious ethics or general ethics. The chapter submits that engineering ethics is an autonomous ethics even if it has values that resemble religious or general ethics.

INTRODUCTION

Anthropologists have not found any tribe that has no religion. Religion and language constitute social institution. Institutions are governed by norms, and norms are treated as values. This amounts to saying that we have not found any society without norms and religion. Thus, there is nothing to surprise if we find societies practicing religious ethics. In India, we have Hindu ethics, Christian ethics and Muslim ethics to name a few. Centuries together, these religion-based ethics have been in

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practice by individuals, if not all, at least religious followers. In the ancient times, it was observed that religious ethics were neither exhaustive nor adequate to perform each and every task, especially a professional task. So, along with religious ethics societies were expecting professionals to practice professional ethics. Professionals were expected to serve the society as a whole, and not a few religious groups. Thus, it is advocated that professionals should stick to their code of ethics when they engage in their professional tasks. In India, we find "business ethics" that is enshrined in Arthashastra[1] and Manusmriti,[2] medical ethics in Caraka Samhita (Loon, 2002 & 2003). Further, ethics are also found in the Gita,[3] e.g. nishkamakarma[4] and varnashrama dharma.[5] Pancatantra (Lechner, 2003) also teaches ethical norms through stories. Furthermore, we find ethics of Jainism and Buddhism with comparable practices. All these ethical documents have religious and metaphysical foundations. These norms are meant for Hindu society, unlikely to be appreciated by other societies. For instance, "duty" based on *varna* and *ashrama* will not be acceptable to the members of non-Hindu societies. But imparting professional knowledge need not be restricted to any caste or community.

Like any other religion, one could find an outline of Christian ethics in Bible. One among others is to work six days in a week and take rest on Sunday (Cunningham, 2008, pp. 233–35). For Christians all actions are moral actions, as a very insignificant action as judged by us might turn out to be an important action from a moral point of view (Cunningham, 2008, p. 25). Without the provision to evaluate which action is moral and which is morally neutral, life would become quite tough for individuals. Christian Ethics also has a stand on divorce. Catholics do not generally permit divorce. Similarly, they do not approve homosexuality as well (Adair, 2007, p. 706). These ethical norms are based on Christian ethics. Bible is the main source of Christian Ethics.

The major sins recognized in Islam are killing human beings, adultery, not performing the Hajj, drinking alcohol, theft, gambling, suicide, telling lies, bribery, etc. Homosexuality is not permitted in Islam (Birgivi, 2005, p. 305). Certain disciplines are enforced on the followers. They are supposed to pray five times facing Mecca every day wherever they are in the world. Adopting the method of birth control is going against the wish of the God. Rispler-Chaim (1989, pp. 203–4) claims that the main sources of ethics are Quran, the Hedith the oral tradition as transmitted by companions of Mohammad and the Sharia Islamic law developed by jurists on the basis of Quran and Hedith. If there is any difficulty in getting the answer to the moral issue, one needs to go back to the Quran and solve the problem. Medical professionals too are supposed to treat the patients without going against the ethics of Islam.

SECULAR ETHICS

We do find several attempts that have been made historically to provide secular foundation of ethics. We may mention some of them. Socratic or that of Aristotle's ethics can be considered secular ethics. Socrates claimed that if one knows what is good, (s)he would act in a just manner. Given this innate good nature of a human being, it is inevitable for an individual to act in a virtuous manner provided (s)he knows what is good. But an individual can be ignorant about what is good. This general claim that virtue is the knowledge of the good does not help much in the professional context. Aristotle's ethics avoids extremes and preaches the middle path, and human beings must act with least effort morally once if they know what the right action is. In order to achieve this, habit formation becomes necessary. Virtue thus becomes dispositional. The goal of a human being is happiness according to Aristotle. Every virtue he recommends, such as courage, wisdom, temperance, friendship, etc., enhances happiness in the individual and society.

This theory is too broad to cover the virtues in the profession. However, in several professions we do recognize certain virtues. For instance, a doctor cannot be an impatient person. He is expected to make the patients comfortable through his interaction and behaviour. There is not much difference between the general ethical recommendations for individuals and professionals except that what is golden mean between coward and rash for a soldier is different from an ordinary citizen. Courage is supposed to be the golden mean between coward and rash behaviour. A soldier should not get frightened if the soldier of the enemy country has a gun in his hand, but an ordinary citizen may get frightened; may lack courage to face the enemy. Adults might have more courage than the children. Even if there is some difference between the mean for a professional and mean for an ordinary person, the case for professional ethics cannot be made within the Aristotelian framework. One cannot explain why preferential treatment is given to enforcing officials. If the traffic rules are such that one should stop when the signal is red, why should it not apply to fire-fighting vehicles, ambulances and ministers?

Immanueal Kant (1724–1804) too gave us what is known as rational ethics. He spoke of the kingdom of ends and dignity of human being. Given the dignity of human being, it is our duty to treat all individuals equally even though we are related to each one of them differently. In order to eliminate favours that might creep in in our treatment of individuals, Kant devices a mechanism; this is called universalizing. A desire is taken as maxim and we wish the same for others as well. If I want others to help me, then we wish the same for others that if others need help, they too must have the right to get the help from us. If I borrow money from others and promise to return the money when I have, and if subsequently do not want to return the money even if I have, then one is not applying the same principles to all including myself. This inconsistency in our application of the principle can be identified if we attempt to universalize the maxim. If my desire not to return the borrowed money is universalized, what follows is that no one who has borrowed money needs to return. If this is the notion of borrowing money, then borrowing money amounts to getting donation or gift. Thus, we have eliminated the very concept of borrowing money when we universalize this desire of ours. Thus, the institution of borrowing is abolished in the ethical domain. This is self-defeating. If we universalize the opposite desire that I must return the money I borrowed, one could consistently universalize without abolishing the institution of borrowing money. Thus, Kant would argue that a rational person would uphold that money borrowed must be returned instead of abolishing the institution of borrowing for selfish reason. Promise keeping is a moral obligation in all contexts; borrowing money is a special case under promise keeping.

This rational ethics of Kant is a general ethics, which covers all walks of our life. In a professional situation, the professional is placed differently from an ordinary individual. For instance, a pilot cannot afford to take a nap when he is flying over night, whereas the passengers could do that. Similarly, a watchman has to be alert all the time when he is doing his duties. A professional context is not the same as a normal context. Given this, the desire of a professional cannot be the same that the ordinary individual would have it. Universalizing a professional's desire would not cover the non-professionals; furthermore, it would not cover other professionals as well. The amount of money a nano scientist would need to establish a good lab would be different for a linguist who would like to establish a good language lab. Universalizing the need of a nano scientist would not naturally cover other scientists. Thus, no professional can effectively find the professional value following Kant's procedure. Kant's ethics is known as universal and rational ethics, and would not cover the domain of professions.

Let us now turn to utilitarianism to examine another attempt to found ethics on a secular

foundation. Many, especially in a democratic country, uphold one form of utilitarianism or the other. Rule utilitarianism is more convenient in the sense that the amount of attention and effort to measure the consequences of an act is minimized in this as it makes use of the earlier experiences in formulating the rule. Thus, it becomes principle-based ethics. The sole aim of this principle is to promote happiness and minimize pain. We also have act utilitarianism, which may not be used always but in special situations we consider the cost and benefits. If there is a proposal to build a dam against a flowing river, we might follow the utilitarian principle to calculate the profit and loss. One could speak of quality and quantity of pleasure and pain. Thus, an action is declared right if it promotes more happiness and reduces pain. Jeremy Bentham (1748–1832) developed a hedonistic calculus to measure the consequences of a proposed action.

Utilitarianism does not distinguish ordinary individual and a professional and their actions. Certain actions can have lasting consequences and certain actions may not have the same result. For instance, a civil engineer, who builds a dam, may have lasting consequences in terms of irrigating large amount of land and production of hydro-electricity that could have good consequences in comparison to a barber whose haircut would have limited good consequence. Furthermore, there are professions that cannot be measured in terms of happiness at all, for instance a postman may not enjoy his profession at all, but might be doing it for the sake of earning the livelihood. Some professions might be highly paying and some may not, yet the society might need all these professionals. For instance, a company CEO might get high salary and, in contrast, a cobbler might get paid very less. Measuring actions of professions and professionals in terms of happiness and reduction in pain they would produce would not give us the estimation of what is morally a right action and what is a wrong action. Therefore, utilitarianism too is a general ethical theory that might marginally cover professional domain but not satisfactorily.

Thomas Hobbes (1588–1679) gave us his theory of social contract. This theory too gives us a general theory about ethics. In order to make his point clear, he invokes a thought experiment. Assume that there were no norms and every individual was free to act the way one wanted. This he calls the state of nature where only the law of the jungle prevailed. At least in the animal kingdom, law of jungle is tolerable because animals do not kill others unless there is the issue of domination or food. In the case of human beings, even the weakest individual is a potential danger for the strongest; even the weakest is capable of killing the strongest with appropriate plan. That is to say, even the strongest has to live with life threat from every corner. This means, one is haunted by the fear of death all the time. This state Hobbes calls the state of constant war. Thus, in order to avoid this situation, by sacrificing some freedom every individual buys some security of life. This is called social contract where individuals come with some norms of behaviour where killing anyone is forbidden and mutual co-existence is granted. However, simply living is not possible without security for other social aspects such as food, shelter, sex, right to property and other human needs. Thus, by sacrificing more freedom, human beings achieved more security in the society. This is called social contract with all the important norms in place.

Social contract theory can explain why there are norms, but cannot found professional norms that differ from one another. It is not the case that one cannot survive without a professional, but a professional can serve us better. One cannot think of state of war in the context of lack of a profession. However, one could think of sub-contracts between professionals and clients. This of course would be to go beyond the social contract theory in the sense that sub-contracts are voluntary and not a necessity.

There is the common ground covered by religious ethics and the secular theories of ethics mentioned earlier. It so happens that major religions teach cardinal values in a similar manner and the secular theories too emphasize such values. Truth telling would be an ethical value in both religion-based ethics and secular ethics of Kant, Hobbes and J. S. Mill. No developed religion would tolerate adultery, killing, theft, and so on. Birth control is not appreciated in most of the religions as such an act goes against the wish of God. Homosexuality too is not appreciated, though it is being tolerated more and more these days. However, birth control could be defended on utilitarian grounds although Kant and Hobbes might find it difficult to defend it. Behaviourally we may find appreciation for several things common to different religions such as prayer, cleanliness, helping others, being kind to others, truthfulness, and honesty, etc., and the same may be promoted by different secular theories of ethics. We generally call all these guidelines general ethics although the origin of these values may lie in religion or in secular ethical theories.

We normally take the society to be the sanctioning authority of general ethics. However, the secular ethical theories take individuals to be the authority. In Kant, it is the moral agent who has to come to the conclusion of what is ethical and what is not. In social contract too, it is the individual who enters into contract. In the utilitarian point of view, the individuals and society together can decide what is ethical and what is not. The sanctioning authority in general ethics seems to be the society at large and not individuals. As the ethical values that are upheld by the society are not in conflict with religion and other secular theories, ethical values of general ethics are not questioned.

ERA OF PROFESSIONALIZATION

Modern science and technology have, directly and indirectly, brought many changes in the modern societies. Survival itself requires technological knowledge. Banking operations, booking of e-tickets, e-shopping, e-books, etc. have become common. We need to know how to handle computer, mobile and other technological gadgets to survive in the modern society. Human population has multiplied several folds in the present century and the need for food, clothes and housing has also increased proportionately. In order to bring efficiency and avoid wastage of manpower and resources, one has to professionalize, whether it is food processing, education, health service or any other aspect of human existence. Division of labour, especially in the area of science and technology, becomes the norm of the day. Research and innovations are done in the most advanced areas of bio-sciences and nano-technology. Similarly, advancement is made in the satellite technology revolutionizing communication. Any country that has cutting-edge technology would have economic and political edge over other countries.

To reap the fruits of science and technology, management gurus suggest mechanization, increased efficiency at various levels, reprocessing of the waste wherever possible, specialization and systematization of production and distribution systems and customer satisfaction. This is achieved with training and hiring qualified people. Education system is not able to provide skill-oriented, ready-to-be-employed individuals. Hence, training becomes an important factor in increasing production and sustenance of quality of products and services. The best way to serve the society is to specialize and professionalize. A professional has special knowledge and training; he has special rights and duties towards public at large or his clients. S(he) is a member of a professional body, which ensures that professionals follow their codes of ethics and, if need be, modify the code of ethics. The speed at which society is

changing has also brought about the change in the attitude of individuals. Not only do human beings want to travel fast, they also want to have speedy communication. Similarly, our lifestyle also has changed. We want speedy recovery if we are suffering from some ailment. Science and technology has brought irreversible changes in the society and one of the consequences is the inevitable division of labour and specialization. Hence, we have professionals of various kinds and new professions are emerging decade after decade. For instance, there was nothing called computer engineering some decades ago. Environmental engineering drawing individuals from chemistry, civil engineering, earth science, etc., emerged as an independent engineering branch only about three decades ago. Electronics itself is not many decades old. Information technology is a separate branch of engineering; telecommunications too is different from computer science and engineering. Nano-technology has emerged only in this decade of the twenty-first century.

NEED FOR PROFESSIONAL ETHICS

The modern Indian democratic society does not recognize a professional based on caste or position in the society as was done centuries ago. The religion-based ethics does not do full justice to a profession because there are differences in their approaches to their professions based on religion. For instance, the education system as visualized by Christians, Hindus and Muslims is different. Science, for instance, could not make progress in some areas as the Christian religion conflicted with scientific view. Hindus could not teach Vedic insights to all students equally as they believed in different Varnas. Muslims restricted their teaching of science in Madarsas because the scientific belief such as evolutionary theory comes in conflict with the teachings of Quran. Medical ethics, for instance, differs if we follow the religious teachings of Christianity, Hinduism and Islam. Early Christian medicine to the natural and supernatural modes of healing found in the Bible (Lazarou, Vol 6 number 4 p. 2). Ayurveda (Sharma, 2002, p. 3) found in Hinduism and Islamic medical ethics (Rispler-Chaim, 1989, p. 204), based on Quran, differ from each other on certain aspects.

General ethics as discussed earlier consists of values such as truth telling, help the needy, promise keeping, non-violence, not stealing, not involving in adultery, etc., and would not remain the same in the professional contexts. If we apply the general norms accepted by all to a professional, it might become a disservice to the professional. For instance, keeping the confidentiality goes against the general ethical norm: tell the truth. Doctors, attorneys, journalists and business managers have to keep certain information as confidential. If they have to practice truth telling in their professional behaviour, they would be treated as bad professionals. Insider trading is a punishable offence in certain countries. CEOs of corporate houses who have rights to be secretive and not divulge the essential information to anyone else other than the board members, if they leak the information selectively, such acts are punishable. Similarly, enforcing officials might need special powers to arrest individuals. Normally, one has the right to be free, but this right might have to be suspended by the enforcing officials if there are grounds to do so. It would be unethical to keep anyone in confinement, but an enforcing official must have the right to do so in order to be an efficient and good professional. One would find the need to grant special rights to professionals to perform their duties effectively when we closely observe any profession. Also, we find that their training, the responsibility of the job, the risk involved could also be different. In certain professions where government functions only as an enabling institution; the right to charge fees, issue appropriate certificate could also be there with the professionals. In order to facilitate all these,

professionals have to be treated differently from the ordinary citizens of the country.

In order to facilitate professional service, we have different organizations prescribing different professional codes. We know the medical council of India has prescribed certain medical codes in 2002 (Published in Part III, Section 4 of the Gazette of *India*, dated 6 April, 2002).[6] Legal profession in India is governed by the codes approved by the bar council of India.[7] Institution of Engineers (India) would deal with several professional issues and codes of several engineering branches.[8] Almost every developed professional body would come up with specific codes of ethics to serve the society better. This would also help the clients to relate to professionals better. In case there is a legal issue between the professional and the client, the professional codes can help the judiciary to make correct judgements.

Professionals may belong to any religion, speak any language or belong to any sub-culture, yet all of them need to accept professional morality. If morality is based on religion, language and culture, etc., then it is impossible to work out the professional morality. The codes that belong to a profession identify the rights and duties. There are consumer courts that punish the professional if the professional has been negligent and irresponsible in practicing his/her profession.

ACQUIRED MORALITY

Freedman (1978) believes that professional morality is acquired obligation (p.5). As citizens, we are expected to behave in a certain manner. This is what is called general ethics irrespective of the religion we practice. Truth telling, non-violence, helping the needy, promise keeping, respect for others, etc., are expected from every citizen and ethical person. We have the enabling institution of promise in our general ethics. This institution allows us to have special contracts that can go against general ethics as well. Thus, we can create contradiction in morality (Freedman, 1978, p.8). To grant some special privileges to professionals such that they can perform better in their profession is to treat them differently from the ordinary citizens. This leads to inequality in the general ethics, but serves the profession better. As serving the society is the main feature of any profession, making a professional more efficient and effective by granting them special rights is nothing other than serving the society better. How much privilege should be given to a professional is a matter of debate, but professionals ought to have special rights is not contestable. Tell the truth belongs to general ethics, but confidentiality belongs to professional ethics. There is conflict between these two norms and a professional cannot be questioned if he/she refuses to divulge certain information that is considered to be confidential except in the case of a judicial probe.

When a professional enters into his/her profession, he/she is bound by the codes of ethics of that profession. He/she takes an oath that he/she would serve the society without any personal bias and prejudices at the time of convocation. He/she is made the member of the organization of his/her profession. If Hobbes and others thought of social contract, we need to think of sub-contracts as and when the situation arises. In fact, when a professional and his/her clients come together, there is a contract. The fees are decided on the basis of the understanding between the two. Having agreed to render the expert service, a professional is bound by this obligation. Thus, any new profession is born; new codes of conduct would be introduced at will by the members of the profession and sometimes approved by the legal institution. There is enough freedom and autonomy within the social framework to recognize a new profession if the need arises.

ENGINEERING ETHICS

Engineering appliances help human beings in several ways. They help human beings to minimize the time, energy and effort to do various tasks. Engineering products are thus not treated as value neutral. They are treated as either good or bad when people get benefit from the product; the product is treated as good and when disasters occur, it is treated as bad. Good and bad judgements on engineering artefacts make an impact on engineering profession. Given these situations, engineers' responsibilities towards their profession increase. As the impact of technology can be heavy, one needs to rethink before introducing a new technology. For example, whereas mobile revolution is a celebrated phenomenon, the radiation effect on the human mind is found to be damaging the brain or other vital organs; it would not be less than devastating.

On the other hand, an engineer or a group of engineers cannot design an artefact without taking any risk. There can be danger at the level of design. If the design is faulty, it can have ill effects on the individuals who use such a technological product. The engineer and the technologists have to ensure that the error in design is minimum. There is the human error that comes into picture when one uses a technological product. Ergonomic factor too comes into picture while designing a product. For instance, when a computer was designed, the keyboard was not appropriately designed. Several experiments went on in re-designing the key boards to suit the ergonomic principles of the human hand. Similarly, the speed at which human beings can respond to a stimulus also need to be taken into consideration when one designs air crafts, fast moving vehicles like bullet trains and so on. There is also limitation of concentration of the human mind. It is impossible to drive a car hours together. The sense organs develop fatigue and the mind can stop responding.

Some of the large-scale productions would have environmental consequences. Water is used as a cooling mechanism in most of these large-scale industries. Some of the chemical processes require water to dissolve certain chemicals in order to segregate the constituents. If burning is an inevitable part of the process, then the fume and the gas would pollute the air. In some of these industries, the sound pollution would be inevitable. Thus, the industrial design should be such that we minimize the air, water, soil and sound pollutions.

Due to technological faults and due to miscalculations and human errors, large-scale accidents can take place. The Fukushima nuclear accident due to major earthquake and tsunami hitting Japan on 11 March 2011 is a recent example of technological failure due to design and unanticipated natural calamity. Apart from human deaths, the task of limiting the leakage of radio-active material was the biggest challenge. Chernobyl nuclear accident is another case worth mentioning. On April 26, 1986, reactor four at the nuclear power plant near Chernobyl, Ukraine, exploded, releasing radiation several times more than the bombs dropped in Japan in World War II. This accident was largely due to error in human decision. In 1984, the Union Carbide pesticide plant released poisonous gas, which spread near Bhopal killing thousands of human beings and animals. This accident could be attributed to the problem of design, negligence and lack of adequate safety measures. The space shuttle Challenger is another example of technological disaster. On January 28, 1986, the space shuttle Challenger broke into pieces killing all its seven crew members immediately after launch. The accident is partly due to faulty design and negligence.

It is not difficult to get into specifics of each engineering profession. For instance, in Computer Engineering, the administrator will have the mechanism to know the details about each and every user file on the machine if it is networked. It is also equally questionable if the software malfunctions after it is sold. Pirated software is yet another ethical issue. No one can deny the destructive power of computer viruses. Worms

these days are capable of spying and installing unsolicited software. Spams in the e-mails and pop-up advertisements while surfing are another ethical problem. These are not very different from cheating in an ordinary parlance. Criteria that have to be applied are different. When a thief steals something, the owner would lose it in general ethics. But in computer domain, piracy is theft without losing the original. Thus, theft has to be defined differently in computer ethics.

Initially, there was only military engineering. Civil engineering as a branch of engineering began when the know-how of construction of bridges and roads etc. was applied to social needs. Today, we have several branches within civil engineering such as construction engineering, structural engineering, geotechnical engineering, transportation engineering, surveying, water resource engineering, environmental engineering, municipal engineering, tunnel engineering, coastal engineering and material engineering. Although all these branches within civil engineering exist, their emphasis, expertise, etc. differ from one another. Similarly, we might need different codes of ethics for each branch of civil engineering to handle specific situations. The problem with construction engineering would be different from the transportation engineering. Though both might deal with accidents due to negligence, the type of negligence would be different. The risk factor would be there in both, but to what extent the risk is permissible might differ. Computer aided design may be used in both, but what level of accuracy can be maintained in the design may be an important issue.

It would not be much difficult to list the ethical issues involved in chemical engineering. As chemicals can react with environment, careful use of acids would be important. Some of the chemicals are dangerous to life forms and hence appropriate precautions have to be taken. Chemicals can pollute water, air and make land infertile. Drugs are pushed in the market even if so many varieties are not needed. Corrosion due to chemical fumes is well known. It can damage buildings or iron structures. One chemical factory in the vicinity is enough to harm human beings and animals as the chemicals pollute the environment; earth, water and air and living beings are sensitive to chemical compounds and acids.

Mechanical, Electrical, Aeronautical engineering are also well-established branches of engineering. A problem with the design can trouble all these branches. Risk factor too is linked to the design part. Human factor is always there when we use any of these engineering products. Negligence could lead to accidents in all these branches of engineering.

Genetic altering of seeds and food items can lead to unwanted consequences. No doubt that we are able to increase the size of tomato, brinjal and other vegetables and fruits, but there remains the question of possible bad effects of consuming such genetically altered vegetables and fruits. Biotechnology is a new engineering branch, which emerged in the last decade. Within engineering as well, new branches of engineering can emerge if the need demands. One could think of combining different sciences and engineering branches to have a new branch of engineering. Nano-technology is being recognized as a new branch of engineering in this decade. Experts from electronics, physics, metallurgy and chemistry can come together and explore the whole field of nano-technology. Another example is that of engineering physics. It emerged as a branch of engineering using physics, chemistry, metallurgy and computer science.

Like any other profession, engineering ethics too is born in a situation where individuals engaged in a profession needed special privilege. Initially no one perhaps explicitly stated the special code of conduct for any particular profession. As the professions grow because of the demand of the society, professionals also feel the need to have special privileges such that they can serve the society more efficiently and effectively. These privileges are granted if the service they rendered

is more beneficial in comparison to the general obligation.

CONCLUSION

To conclude, we might sum up the main points of our discussion. There might be difficulty in distinguishing religion-based ethics and secular ethics. When we are born, the society puts a stamp of a religion on the new-born baby. Till the baby develops an independent way of thinking, it follows the religious ethics. The limitations in the religion might make the individual think rationally and develop rational ethics as a reaction. But the unquestioned values already learnt might remain with the individual. Some of these general values are common to many religions, and we tend to call the theories upheld by philosophers as belonging to general ethics. The secular theories of ethics do not have the capacity to provide professional codes as some professional codes including engineering codes of ethics go against the norms of general ethics. The conviction that professional ethics must be related to general ethics in some way or the other makes one call professional ethics as applied ethics. On closer examination, one finds that though the values appear to be the same, the criteria used to judge them are different in professional contexts. The sanctioning authority for religious ethics and general ethics are also different. Applied ethics gives us the sense that professional ethics is derived from general ethics. If this were so, there was no need to formulate different codes for professionals. Without formulating different codes for professionals including engineers, we would not have been in a position to grant them the rights they badly need to serve the society better. Without professional bodies having autonomy, these societies cannot guide the professionals including engineering professionals and prevent conflicts between professionals and their clients. Engineering profession like other professions is autonomous and the attempt to reduce it to general ethics or religious ethics would necessarily fail.

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KEY TERMS AND DEFINITIONS

Engineering Ethics: Ethics that are codified by engineering societies.

General Ethics: Ethical values practiced and promoted by the society.

Professional Code: The codes that are listed by the professional organizations.

Professional Ethics: Ethics that are codified by the professions.

Religious Ethics: Ethics prescribed by a religious text or authority.

END NOTES

[1] *Koutilyas Arthashastra* deals with war ethics, duties of different professions such as accountants, spies, and also ethics of business community.

[2] *Manusmriti* is the work of sage Manu who arranged the ethical codes of different professionals: Educators, Rulers, Business community and the physical labourers.

[3] Prabhupada, *Shrimad Bhagavad-Gita.* Retrieved August 25, 2014, from http://bvml.org/SBRSM/books/GITA.PDF

[4] *Niskamakarma* means action without self-centered desire. If we act for morality's sake, such action would be 'niskamakarma'.

[5] *Varna* is four fold functional classification made in *Gita*: *Brahmana* (knowledge seeker), *Kshatriya* (kings and soldiers), *Vaishya* (business community) and *Shudra* (agriculturists and physical labourers). The normal life-span of human beings is divided into four *Ashramas*: *Brahmancarya* (studenthood), *Grahastha* (productive married life), *Vanaprastha* (retired life leading in the forest) and *Sanyasa* (renunciation). The combination of *Varna* with that of *Ashrama*, gives one's duty. The duty of a Branhim's son at the early age is to seek knowledge. The duty of a Kshatriya's son is to learn the art of skillfully fighting the war and so on.

[6] Retrieved July 22, 2014, from http://www.mciindia.org/RulesandRegulations/CodeofMedicalEthicsRegulations2002.aspx

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Section 2

Education

Chapter 8
Ethical Theories and Teaching Engineering Ethics

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ABSTRACT

As an area of academic study, engineering ethics focuses primarily on practical ethical issues. A primary aim of the study of practical ethics is to help students make good ethical decisions in whatever practical endeavors they may undertake, including in their chosen careers. The authors argue that reflection on the sorts of ethical problems that arise in engineering practice should be the starting point, with ethical theory coming into view primarily in this context. This is in contrast to a more "top-down" approach that tries to "apply" theory to practice only after laying out a spectrum of philosophically grounded theories, each of which attempts to give us a comprehensive picture of ethics, as such.

INTRODUCTION

Like 19th British philosopher Henry Sidgwick, we advocate first seeking common points of agreement, shared values at the level of everyday common sense. Invoking theories that attempt to "get to the bottom of things" can provoke unnecessary disagreement that gets in the way of constructive resolution of ethical problems that do not require agreement at the foundational level of our philosophical or religious thinking. Instead, he argues, we should content ourselves, for the most part, with employing our shared values at the level of everyday, common morality.

Engineering ethics is an emerging area of academic study. As such, it is not surprising that there is some dispute about its appropriate content. A common approach is to include some discussion of standard philosophical theories of ethics (such as utilitarianism) in order to provide a superstructure that can be used to identify and resolve ethical issues in engineering.

However, others object that there is neither time nor need to introduce philosophical theories of ethics in courses in engineering ethics (Davis, 2009). Furthermore, they express concern about whether anyone other than a professional philosopher is qualified to teach even abbreviated forms

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of these theories. Philosophers themselves are accustomed to having an entire course to introduce ethical theories to their students, and, even then, they worry about whether they are able to do justice to the nuances of these theories. It is no wonder that few engineering faculty feel ready to deal with the philosophical challenges they may think teaching engineering ethics entails.

Thus conceived, the challenge of teaching engineering ethics seems quite formidable. However, rather than characterize engineering ethics as a sort of "top-down" application of ethical theories to engineering contexts, we conceive of it as a kind of *practical* ethics. How, if at all, philosophical accounts of ethics might contribute to identifying and resolving ethical issues in engineering remains, then, to be seen. We suggest that it is best to begin in the context of engineering practice, reserving the introduction of ethical theories to those moments, if any, when this might actually be helpful in clarifying and resolving the sorts of ethical problems that arise in engineering.

The study of ethical theory as such need not have any particular practical ends in mind. However, a primary aim of the study of practical ethics in engineering is to help students make good ethical decisions in whatever practical endeavors they may undertake as engineers. In this article, we will discuss a recent debate among three well-known philosophers who have given much careful thought to the question of the relevance of ethical theory to the teaching of practical ethics of this sort. This debate was initiated by C.E. Harris (2009a) in his work "Is Moral Theory Useful in Practical Ethics?" This was followed by a series of critical responses by Michael Davis and Bernard Gert, along with replies by Harris.[1]

In his initial article (2009a), Harris discusses the usefulness of utilitarian and respect for persons' theories in framing ethical issues that arise in engineering practice. Sometimes these theories work in concert in supporting views about what should or should not be done. Sometimes they are in tension, if not outright conflict. Even so, Harris argues, they can help us better understand what is at stake morally. He illustrates this with an example that appears in *Engineering Ethics: Concepts and Cases*, an engineering ethics text we co-authored with Harris, Ray James, and the late Michael Rabins (Harris, 2014). Here is how Harris describes the example in his, "A Reply to Bernard Gert" (Harris, 2011, p. 41):

In 1993, it was publicly revealed that Germany's Heidelberg University conducted automobile crash tests, using more than 200 corpses, including more than eight children. The public controversy that followed included a statement from a spokesman for the Roman Catholic German Bishop's Conference, who argued that "even the dead possess human dignity." On the other side, advocates for the tests argued that relatives of the deceased had given permission and that the test data could result in the saving of many lives.

The public controversy took the form of a contest between those who believed that priority should be given to respecting human dignity (including the derivative dignity that should be ascribed to corpses), and those who believed that the promise of the tests to save lives and thus promote the general good was the most important consideration. Both perspectives are partial and inadequate for appreciating the full dimensions of the case. Thus, in order to appreciate the issue in its full complexity, one must consider both perspectives and take into account the limitations of each.

So, does this example support Harris's view that ethical theories have a useful place in engineering ethics? To see why Harris believes it does, it will be helpful to consider how he begins his "A Reply to Bernard Gert":

In teaching ethics, I have found it important to correctly describe a moral problem as it most naturally presents itself to a person in a situation of moral choice. We can call this attempt to cor-

rectly describe the structure of a moral problem an attempt to achieve phenomenological accuracy. Enumerating some of the ways in which moral problems can present themselves will provide the context for my understanding of the usefulness of moral theories (Harris, 2011, p.39).

It is Harris's view that the public discussion of the use of cadavers in crash testing vehicles indicated that both utilitarian and respect for persons theories were at least implicitly in play. That is, a phenomenologically accurate account of these responses could appropriately include some reference to these theories.

Harris concludes his reply to Davis's "The Usefulness of Moral Theory in Practical Ethics: A Question of Comparative Cost (A Response to Harris)" with a final word in favor of including some moral theory in the teaching of engineering ethics: "… it is always possible to tell students and practitioners that in their real-world experience there are a few simple guidelines that they should remember. One of these is that they should be aware that, in cases of moral conflict, the issues will often take the form of an opposition between considerations of harm and benefit to the public on the one hand and considerations of the rights of individuals on the other" (Harris, 2009b, p. 86). Golden Rule thinking, too, has much to be said for it, says Harris. He adds, "These guidelines are as simple as anything Davis presents, perhaps simpler. Students and practitioners will probably not find them unduly technical or forbidding. If they do, they shouldn't" (2009b, 86).

Perhaps it was Harris's use of the expression, "a few simple guidelines," that prompts Gert to say that it seems that Harris is relying on "moral slogans" rather than more substantive and nuanced ideas. However, this seems unfair. Harris's discussion of utilitarian and respect for persons principles is not reducible to "moral slogans" any more than Gert's moral rules ("Don't kill," "Don't deprive of freedom," "Do your duty," etc.) are. Gert's discussion of how his rules should be understood and used rescues them from the charge of being "moral slogans" (Gert, 2004). Similarly, Harris's discussion of utilitarian and respect for persons principles rescues them from this charge—and gives them substance without getting bogged down by the very detailed and nuanced details and debates found in standard philosophical discussions of their respective theories.

Characterizing our presentation of utilitarian and respect for persons thinking in *Engineering Ethics* (Harris, 2014) as relying on "a few simple guidelines" (or "moral slogans") would also be misleading (Harris, 2011). In addition to roughly 15 pages of straight exposition, examples of utilitarian and respect for persons thinking can be found throughout the text. However, added together, this does not amount to a full-scaled presentation of either utilitarian or respect for persons ideas as found in standard texts in moral philosophy. Nevertheless, these theories are presented in ways that we believe are useful and that do not unduly distort the basics ideas underlying the theories in question. Furthermore, as we have said, the rationale for introducing ethical theory to the extent that *Engineering Ethics* does is not to clarify philosophical ethical theory, but to help clarify the ethical issues that arise in engineering practice.

In fairness, it should be acknowledged that the utilitarian and respect for persons ideas discussed in *Engineering Ethics* are not nearly as detailed and nuanced as they are in the standard philosophical literature. Nevertheless, Harris might respond, the more important point to make is that non-philosophers have some familiarity with basic moral ideas that philosophers make use of in their ethical theories. This can be used as an entering wedge for ethical theory to gain some foothold in engineering ethics. How far this should be taken is the crucial question for Harris.

Michael Davis (2009), in "The Usefulness of Moral Theory in Practical Ethics: A Question of Comparative Cost (A Response to Harris)" notes that the 4th edition of *Engineering Ethics*

devotes only a few pages to explaining utilitarian and respect for persons ethical theories. This suggests that the authors envisage users of the text spending as few as four lecture hours in the classroom, whereas Davis claims he needs weeks to give students a good introduction to just one of these theories. Davis's approach is to dispense with ethical theory entirely in practical ethics courses and substitute in their place a set of questions for students that they will recognize as familiar and which call for the employment of *common sense* in addressing the ethical issues under consideration.

We will turn to Davis's alternative approach shortly. Before doing so, however, it is important to clear up two possible misunderstandings of Harris's position. First, for Harris, the point of introducing some ethical theory is gain greater understanding of ethical issues in engineering, not to use engineering examples to gain greater understanding of ethical theories. So, the exposition of ethical theory is practice driven rather than theory driven (Davis, 2009). For example, if the exposition of rule-utilitarian thinking, in contrast to act-utilitarian thinking, leaves something to be desired in light of the decades of critical discussion, which has received from philosophers, this is to be expected. But, the basic question is whether there can be a place for appealing to rules in utilitarian thinking, rather than simply trying to determine the consequences of this or that particular action. The overall utility of, say, rules of the road that support safe, efficient travel strongly suggests an affirmative answer. Taking this into account, it helps to explain at least some of the appeal of utilitarian thinking when formulating public policies and regulations affecting engineering practice.

Second, one function of an ethical theory, says Harris, is to organize and unify our moral thinking insofar as this can plausibly be done. Utilitarian and respect for persons theories are particularly ambitious. Both attempt to articulate a single, master principle that provides a comprehensive grounding for *all* moral considerations. Harris makes no attempt to defend this sort of ambition (quite the contrary). However, he does emphasize the wide reach of both theories from the standpoint of the relevance of their fundamental principles to ethical issues in engineering (Harris, 2009).

In apparent contrast to Harris's use of ethical theory, Davis provides a list of seven questions for students to ask when examining ethical problems in engineering (Harris, 2009, pp.74–75):

- Harm test: does this option do less harm than any alternative?
- Publicity test: would I want my choice of this option published in the newspaper?
- Defensibility test: could I defend my choice of this option before a Congressional committee, a committee of my peers, or my parents?
- Reversibility test: would I still think the choice of this option good if I were one of those adversely affected by it?
- Virtue test: what would I become if I choose this option often?
- Professional test: what might my profession's ethics committee say about this problem?
- Colleague test: what do my colleagues say when I describe my problem and suggest this option as my solution?
- Organization test: what does the organization's ethics officer or legal counsel say about this?

We say in *apparent* contrast to Harris's approach because Davis concedes that his tests correspond, roughly, to a variety of moral theories familiar in the philosophical literature. However, Davis adds, his list of seven questions are drawn from common sense rather than moral theory. So, he thinks, there is no need to introduce moral theory. Still, it would seem that much depends on how the *discussion* of these questions might go. It seems likely that students will want to discuss benefits as well as harms, for example. After all, engineering attempts to bring about benefits, not

simply to avoid harms, and, harms aside, more overall good is better than less. Similarly, as Davis points out, his reversibility test invites reflection on the importance of respect for persons. So, it would seem to be a short step from common sense reflection to something recognizably close to utilitarian and respect for persons theories. However, the direction of reflection is from common sense to theory, rather than from theory to common sense.

Furthermore, the appeal to common sense must also, for Davis, be understood to be an appeal to *moral* common sense if it is to do much work in engineering ethics. For example, the colleague and organization tests would seem to be only preliminary to a fuller moral analysis, as the responses of one's colleagues and organization themselves need to be morally assessed.

In short, depending on the *thoroughness* of discussions of ethical issues in engineering, something rather close to the sort of theoretical models suggested by Harris's representation of utilitarian and respect for persons theories might emerge. However, Davis offers another criticism of Harris's reliance on utilitarian and respect for persons theories. These are only two of many philosophical theories. Exclusive reliance on these two theories may result in overlooking other kinds of moral considerations that are not captured (or not captured well) in these theories. As Davis puts it:

After all, Harris's approach relies on just two theories (each in three varieties). My approach, however implicitly, relies on at least four. Insofar as Harris is right that moral theories are in fact imperfect guides to conduct, my approach must be better than his. All else equal, four different screens should catch more of what we want to catch than two (Davis, 2009, p. 75).

In response, Harris could point out that *Engineering Ethics* does not rely exclusively on utilitarian and respect for persons theories. It also relies on *common morality*, as represented by W.D. Ross's discussion of prima facie duties and Bernard Gert's moral rules.[2] Both claim to have captured a very broad range of familiar, morally important ideas that can be used in evaluating moral decision-making. They offer these considerations, not under the umbrella of an organizing master principle, but as a fairly comprehensive set of basic considerations, neither reducible to one another nor derivable from someone, more basic, moral principle. In short, Harris does not hold that the moral theories to which he appeals are the *only* useful sources of systematic reflection.

In developing our own position on these matters, we have found it helpful to turn to some of the ideas of 18th century Scottish philosopher Thomas Reid and 19th century British philosophers William Whewell and Henry Sidgwick. Despite their differences at the level of ethical theory, all three of these philosophers insist that philosophical reflection on ethics should hold common sense in high regard (Pritchard, 2006). Reid maintains that it is a serious mistake to hold that one needs to be a philosopher or metaphysician in order to understand one's duty. This does not mean that understanding one's duty in particular circumstances does not require careful, clear-headed thinking. It does. But Reid, like Whewell and Sidgwick, insists that practical ethics is well within the reach of non-philosophers.

In the domain of practical ethics, Reid does favor systematic thinking. However, he holds that:

A system of morals is not like a system of geometry, where the subsequent parts derive their evidence from the preceding, and one chain of reasoning is carried on from the beginning; so that, if the arrangement is changed the chain is broken, and the evidence is lost. It resembles more a system of botany, or mineralogy, where the subsequent parts depend not for their evidence upon the preceding, and the arrangement is made to facilitate apprehension and memory, and not to give evidence (Reid, 2010, p. 281).

Such a view of a "system of morals" does not share utilitarianism's aspiration of coming up with a master principle, which organizes and prioritizes all of morality under that principle. But, it does attempt to develop a moral taxonomy of sorts for various areas of moral concern. Although confined to engineering practice, codes of ethics for professional engineers might be viewed somewhat similarly. They have organizing principles, rules, and guidelines. However, these codes are derived from reflection on engineering practice and the sorts of ethical issues typically encountered in that practice. So, it should be no surprise to find a plurality of basic provisions about protecting public health, safety, and welfare, objectivity in reporting data, minimizing conflicts of interest, duties to employers and clients, and the like. And it should not be surprising to learn that, over time, the content of these codes of ethics have undergone changes—in response to complications in interpreting and applying provisions in the codes, as well as to changes in technology, society, and the perceived impact of engineering on the world in which it operates (Englehardt, Pritchard, 2013, p. 165).

Half a century after Reid, William Whewell's *Elements of Morality* still resonated with many of Reid's ideas about systems of morality and the relevance of philosophical thinking in addressing moral problems. Although readily conceding that his book does not present a grand philosophical theory of morality, Whewell insists that he has "tried to make it a work of rigorous reasoning, and therefore at least, philosophical" (1864, preface vii).

In the late 19th century, Henry Sidgwick did write a book in which he defended a grand philosophical theory of morality, utilitarianism. In his famous *The Methods of Ethics* (Sidgwick, 1963), he took Whewell to task for not offering an account that could help us resolve possible conflicts within common morality. Here, in principle, he argues, something like the principle of utility is needed to settle such issues. However, *The Methods of Ethics* offers no practical examples of utilitarian theory serving as a successful mediator. In other writings, essays in practical ethics, Sidgwick was concerned to make some headway with others in resolving difficult moral problems of the day. There he argues that, despite his utilitarian preferences at the level of ethical theory, it is a practical mistake to insist that we first try to "get to the bottom of things" if we want to get somewhere in resolving with others the practical ethical issues of the day; in fact, he worries about our never being able to get beyond theoretical disputes if we allow ourselves to get embroiled in philosophical disputes about the best ethical theory (Sidgwick, 1998, p. 5). Instead, he argues, we should content ourselves, for the most part, with employing our shared values at the level of everyday common sense. This does not guarantee that there will be agreement on all the issues of the day, but it can at least offer a promising start.

A good example of how what Sidgwick advocates at the practical level has achieved significant success is in the area of research ethics, especially in the United States. In the mid-1970s, in response to a number of publicized instances of ethically questionable research involving the use of human beings, the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research was established. Its charge was to formulate ethical guidelines for conducting research involving human subjects (or participants). In 1978 the commission issued its influential Belmont Report, which discusses, in the space of just a few pages, three principles that should be observed in conducting such research: respect for persons; beneficence; and justice.

For our purposes here, it is as important to comment on the *process* employed by the commission in coming up with these principles as the results of that process. The commission's 11 members were quite diverse—men and women, members of a variety of religions, atheists, scientists and non-scientists, philosophers, and public representatives. According to commission member

Albert Jonsen and consultant Stephen Toulmin, the commission floundered at the outset. This is because it failed to observe Sidgwick's advice not to try to "get to the bottom of things." As might be expected, there was no consensus about what should be taken as the grounding first principle(s).

However, when the commission turned to the details of particular instances of ethically problematic research, consensus around what went wrong emerged. Not seeking the informed consent of participants prior to their role in the research, it could be agreed, is a serious problem. Not paying sufficient attention to minimizing the risks of harm to participants was another. Selecting only especially vulnerable populations (for example, prisoners and the elderly) for exposure to those risks was a third area of concern.

Based on their reflections on the set of cases brought to their attention, the commission was able to achieve consensus on three basic kinds of requirements that should be met in research involving human subjects—respect for persons, beneficence, and justice. At the same time, the commission was careful not to overstate the work that these principles can accomplish:

Three principles, or general prescriptive judgments, that are relevant to research involving human subjects are identified in this statement. Other principles may also be relevant. These three are comprehensive, however, and are stated at a level of generalization that should assist scientists, subjects, reviewers and interested citizens to understand the ethical issues inherent in research involving human subjects. These principles cannot always be applied so as to resolve beyond dispute particular ethical problems. The objective is to provide an analytical framework that will guide the resolution of ethical problems arising from research involving human subjects (The Belmont Report, 1978, pp.1–2).

This, rather modest statement is welcome in the context of expected disagreement at the foundational level in ethics. As Cass Sunstein might put it, the commission achieved "incompletely theorized agreement" (The Belmont Report, 1978, pp.123–150). His contention is that often agreement on how to resolve particular ethical issues can be achieved without first attaining agreement on underlying theoretical commitments. The strategy he recommends "enlists silence, on certain basic questions, as a device for producing convergence despite disagreement, uncertainty, limits of time and capacity, and heterogeneity" (Sunstein, *The Belmont Report*, 1978, p. 123).

The idea of "incompletely theorized agreement" does not exclude theorizing entirely. In the case of the *Belmont Report*, the three principles are not advanced as representing complete ethical theories. Some major features of utilitarian and respect for persons theories are highlighted, but the commission quite deliberately resisted ranking these principles into a hierarchy, either subordinating any one of these principles to others among the three or to some higher principle from which these three are derived. Thus, in effect, they adopted Sunstein's "incompletely theorized agreement" approach and heeded Sidgwick's advice not to try to "get to the bottom of things." This, in fact, is how we recommend utilitarian and respect for persons principles be regarded in *Engineering Ethics*. They are regarded, along with Ross's prima facie duties, Gert's moral rules, and a variety of suggested critical techniques as "practical tools" of ethical analysis (Harris, 2014, Ch. 2).

It is interesting to note that early in the 20th century the American Association of Engineers (AAE) employed a technique similar to the Belmont commission in formulating a code of ethics for engineers. The final version of this code reflected the opinions of a practice committee that analyzed a large set of cases in terms of an earlier draft of the code. In his discussion of the evolution of the AAE code, Carl Taeusch, 1926 comments:

After some forty-practice cases had accumulated, the AAE made a compilation of specific principles from the recorded decisions in these cases and then proceeded to accumulate a further set of practice cases authoritatively interpreted by a representative and responsible committee. The Code of Specific Principles is amended as new rulings or decisions are formulated (Taeusch, 1926, p. 101).

Founded in 1915, AAE disappeared in the late 1920s. Disappearing with it was the code's first Specific Principle, formulated after the practice committee had analyzed its first 40 cases: "The engineer should regard his duty to the public welfare as paramount to all other obligations" (101). It took several decades for this duty to the public to surface again in the codes of ethics of major engineering societies in the United States, replacing duties of loyalty to employers and clients as first and foremost. Its reappearance coincided with a number of highly publicized engineering cases involving death and injury to members of the public, as well as the sorts of cases that gave rise to the establishment of the Belmont commission.

The codes of ethics of engineering societies represent consensus among their members regarding the basic responsibilities of engineers. This consensus can be regarded as the highest shared set of ethical standards among these practitioners. This consensus falls short of agreement about this or that ethical theory (for example, utilitarian or respect for persons theories), but this does not preclude making some reference to utilitarian and respect for persons that are central to those theories. Furthermore, as a consensus document, an engineering code of ethics should not be expected to match all of the moral commitments individual engineers may have regarding their roles as engineers. So, although discussion of engineering codes of ethics is important in engineering ethics classes, some indication of where one might turn for further articulation of his or her moral aspirations can be helpful, as well. Here some discussion of ethical theory may be useful for those undertaking careers as engineers.

At the outset of this article, we addressed the concern that the inclusion of ethical theories in courses in engineering ethics would pose a formidable challenge. Engineering faculty see themselves as ill prepared for such a task. Philosophy faculty worry about having sufficient time to do justice to ethical theory in a course in engineering ethics—and to its possible applications in engineering practice. However if we conceive of engineering ethics as a kind of *practical* ethics, this reminds us that the primary aim should be to help our students obtain a better understanding of how they might constructively address the sorts of ethical problems that arise in engineering. Here we believe that it is best to begin inquiry in the context of engineering practice, and reserve the introduction of ethical theories to those moments when they might be useful in clarifying and resolving those ethical problems.

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KEY TERMS AND DEFINITIONS

Applied Ethics: The application and study of moral behavior within the professions and practices.

Belmont Commission: The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research established in 1978. Their findings, The Belmont Report finds three principles that should be observed in conducting research: respect for persons, beneficence and justice.

Code of Ethics in Engineering: The codes of morality for professional and practical behavior in engineering societies. The codes of ethics for these societies represent consensus among their members regarding the basic responsibilities of engineers. This consensus can be regarded as the highest shared set of ethical standards for engineers.

Engineering Ethics: The study and application of moral behavior within the professional and practical field of engineering.

Ethical Theory: One function of ethical theory is to organize and unify moral thinking and study.

Respect for Persons Theory: A comprehensive moral theory most closely connected with the writings of Immanuel Kant. Within this theory we are to act in ways that all others could perform the same behavior. This includes never treating persons merely as a means to an end, but as ends in themselves.

Utilitarian Theory: A comprehensive moral theory most commonly associated with the writings of John S. Mill. Often termed the greatest happiness principle, persons are asked to morally consider the greatest good for the greatest number of individuals.

ENDNOTES

1 The entire debate is published in *Teaching Ethics*, Vol. 10.1, 2009 and Vol. 12.1, 2011.

2 For a brief presentation of W.D. Ross's prima facie duties (regarding keeping promises, justice, and beneficence, for example) and Bernard Gert's moral rules (not harming or killing, not depriving of freedom, keeping promises, for example), see pp. 32–33 in Harris, C.E., et al., *Engineering Ethics: Concepts and Cases*, 5th ed. (2014) (Belmont, CA: Cengage).

Chapter 9
Teaching Ethics to Engineering Students in India:
Issues and Challenges

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ABSTRACT

Most engineering colleges in India have integrated ethics courses into their curriculum for the reason that students may develop an ethical ability to engage in sound decision making. However, there are differences noticed in defining the concept of "ethics" by the engineering students and the teachers who teach them ethics. Often, it is observed that students' positions with regard to ethics courses are egoistic pragmatism while the teachers follow idealistic pragmatism. This ideological difference makes teaching ethics to engineering students a difficult task and thus undermines the effectiveness of the ethics course. The major objective of this chapter therefore is to examine the extent to which the "gap" can be merged and make the students more ethically responsible. It also helps to achieve more job satisfaction for teachers. Finally, the chapter discusses some suggestions to make engineering students more ethically sensible.

INTRODUCTION

Little research has been done on the ethical dilemmas faced by teachers who teach ethics to engineering students. Due to globalization, the importance of ethics has been increasing in the engineering profession. Often our society bestows special privileges and status to professionals including engineering professionals, which are not given to "ordinary" people. It has been argued that engineering is a responsible profession and thus responsibility is bestowed on engineers. They have certain responsibilities toward society among others. To increase their awareness of their social responsibilities, the All India Council for Technical Education (AICTE) has taken initiatives by adding the course of "Professional Ethics" to the engineering curriculum (http://www.aicte-india.org/downloads/mugtextiletechnology.pdf). Most engineering colleges in India therefore have adopted Professional Ethics or Engineering Ethics as part of their curriculum so that students may develop an ethical ability to engage in sound decision-making.

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However, there is a difference in defining the concept of ethics by teachers and students. What is "acceptable" for students is "unacceptable" for teachers and vice versa. For example, helping one's friend to copy in the examination hall may be considered as ethically right by students, but not by the teachers. It is based on the huge gap between teachers' and students' understanding of the definition of the term "engineering." For most engineering students, "Engineering" is only a means to get a good salaried job. The teachers who teach Professional Ethics or Ethics in engineering education define "Engineering" as a means to ensure the safety, health, and well-being of the society. Unless this ethical explanatory gap is closed, the major objective of preparing young engineers to be socially responsible and ethically sensitive will be worthless. It is also supported by the students' attitude that they do not need to study any humanities courses, because these disciplines are unimportant for designing, developing, or manufacturing an engineering product. Moreover, there are engineering students who believe that they know what "ethics" is and what is "ethically right or wrong," and so there is no need to study an Ethics course. This type of attitude makes teaching human values and ethics to engineering students a tedious job. Thus, the major objective of the chapter is to examine the extent to which the so-called gap can be merged and thereby make the students more ethically responsible. To understand this gap, it is important to analyze the various issues and challenges faced by teachers who teach Ethics.

STATE OF THE ART

The need for ethics in engineering was first realized in the 19's by engineering societies (for e.g. The American Institute of Electrical Engineers in 1912 and The American Society of Mechanical Engineers in 1914) from different parts of the world. In this context "ethics" means understanding the distinction between the "rights" and "wrongs" in the engineering profession and the art of absorbing values that are necessary for engineering profession. Though various engineering societies have adopted a formal code of ethics during the 19's, the Institution of Engineers in India only implemented it in 2004 (http://www.ieindia.org/archive.aspx). At that time, these bodies found that there was a lack of ethical sensitivity among engineering professionals, which had been reflected in many disastrous events in the form of bridge collapse, building collapse, etc. Though the situation has been changing overtime, continuing instances of unethical practices in the engineering field shows that the situation has not changed much and so it has to be improved. Still, many instances show that corruption is widespread in the engineering section. Though engineers recognize corrupt situations, they prefer to keep quiet. The construction field is a good example. It has been reported that engineers have been charged with dereliction of duty due to building collapse in Thane (Times of India, 2013). In 2014 also, building collapse has been reported in Bombay (Times of India). In the same year (2014) a building collapsed after catching fire in Chandigarh (India Today). These types of incidents reveal that engineers have received inadequate training or they lack virtues themselves in order to distinguish between "what they ought to do" and "what they ought not to do" in their profession. Consequently, there is an urgent need to understand what is lacking in the graduate engineering program. In addition, inclusion of the Corporate Social Responsibility (CSR) mandate under the new companies Act 2013 has augmented the relevance of pursuing ethics in engineering. It is the ethical responsibility of an individual to take care of his or her society.

To train the students how to distinguish between "what they ought to do" and "what they ought not" in the engineering profession, Ethics has been inculcated into the engineering curriculum. The assumption is that if students are trained for ethical responsibility in their graduate program,

they will demonstrate these abilities in their profession. Moreover, it helps to turn students into enactors of the great changes that the world needs, to encourage them to work for the common good and to go beyond strictly private interests (Didier & Huet, 2008). Most colleges have developed various teaching methods and course contents to teach basic values in their students. Many studies have been conducted in the area of engineering education and ethics, especially in the area of pedagogy and curriculum design. Here, the question remains—how should the engineering students be prepared for their profession? Bowden (2010) in his study has described research underpinning a course. The course is based on the assumption that identifying the major ethical issues in the discipline, and subsequently presenting and analyzing them in the classroom, would provide the future professional with knowledge of the ethical problems that they are likely to face on graduation. Another study by Zhu (2010) examines engineering ethical studies in China and points out that it is constituted by a dialogue between traditional Chinese value system concerning engineering and modernist perspectives influenced by both Marxism and more techno-scientifically advanced nations as a result of global technology transfers and economic exchanges. Various authors have suggested different teaching methods to teach ethics. Importance of role-playing as a teaching tool to teach ethics to engineering students has been pointed out in a research, especially for a class of exceptionally wide cultural diversity (Prince, 2006).

Some studies show that if students were informed about the ethical issues in engineering profession beforehand, they might be able to take a better decision. In this context, Colby and Sullivan (2013) report the need for informing educators about the kinds of issues and dilemmas students should be prepared to handle. Another thing is that when providing case studies or scenarios of ethical dilemmas in engineering, those should not be too narrow and simplistic. For example, an engineer encounters a conflict of interest when attempting to support work he performed for his past employer (OECE 2014). In his study, Bucciarelli (2008) points out the issues in adopting the pedagogy of using scenarios and open discussion framed by the codes in teaching ethics to engineering students. According to him, these scenarios and this framing are seriously deficient. It lacks complexities of context and has focused on individual agency, while reflecting too narrow and simplistic a view of the responsibilities of the practicing engineer. Here, the issue is whether the ethics in engineering curriculum should focus on relationship between individual engineers and their clients, colleagues, and employers or on the collective social responsibility of the profession (Herkert, 2003). However, the collective social responsibility covers professional responsibility treating everyone including the individual human being and environment with respect. To understand this collective social responsibility one should comprehend one's own individual responsibilities and duties first. Study of ethics facilitates this.

The question that arises here is whether our engineering education system can really assure ethical quality in engineering education and how it can ensure this. Ethical quality in this context means developing ethical sensitivity. Ethical sensitivity is the ability to understand the ethical implications of one's decision-making. These are the characteristics or attributes needed to be possessed by both teachers and engineering students. The challenge is that there are students who are less interested in ethics, because for them, learning ethics has no utility. Before enrolling in any humanities course, they check how the course would be useful for them to get admission to post graduate programs in foreign universities or getting accepted by MNCs (Multi-National Companies). That is to say, ethics is not the desirable goals they strive to attain, but only a means to attain good career prospects. They believe that to get admission in foreign universities, it is important. Accordingly, students' ideas of ethics also

alter. For engineering students everything other than engineering is without utility. Accordingly, "right" and "wrong" of an act is understood on the basis of its materialistic outcome and not on the basis of achieving any values through the act. In other words, learning ethics is unimportant if it does not lead to any materialistic result. There are even engineering faculties who support the similar idea that engineers do not need to base their work around values such as empathy or caring considerations. In their research, Strobel, Hess, Pan, and Morris (2013) point out that faculties and those who practice engineering perceive empathy as a utilitarian construct, having value in so far as it provides some edge, be it in terms of promotion, advancement in administrative rank, or better meeting a client's need.

In addition to this, there is an issue of lack of cordial relationship between teachers and students in engineering colleges. There are various reasons for this. One of the reasons may be the mismatch between the expectations of students from their teachers and vice versa (for example, students' expectations about teaching quality). Often students claim that ethics is a subjective course, so whatever they write as answers is correct. (Subjective here means the answer to a question depends on the personality of the answering person. There is no objective solution to the questions in ethics, unlike engineering or science subjects.) The teachers who teach ethics or similar course complain that students lack the ability of critical analysis of an issue. For instance, when students are asked to write an argument for or against an issue, some are not able to do so. The reason for this may be due to their years of training in answering objective type questions to prepare them to clear various engineering entrance examinations. Ethical reasoning always requires the ability of critical thinking. Teaching ethics becomes more difficult if students lack critical thinking. All of the above factors affect the relationship between teachers and students and the absence of a good rapport affects the effectiveness of any communication process. The divide between teacher and students begins with the basic principles or standards which decide "ethics" or "what is right." It deepens further with the special status given to the discipline of engineering by Indian society. Here, the question that arises is: with the above circumstances to what extent can teachers teach ethical, social, and professional responsibilities to engineering students?

THE EXPLANATORY GAP

Intricacies in Defining Individual Ethics

It is significant to analyze how we assess ethics in this context. It has been argued that ethics is acquired through the process of socialization when children learn their experience with peers, from observation of adults, and by instructional stories, such as fairy tales (Moskalenko, 2009). In Indian society, it is difficult to assert that whatever a child learns through socialization is ethical. In our society there is no consent regarding the definition of "ethics." It is based on class, caste, religion, gender, profession, social status, etc. For example, "honour killing" is ethically right for some people (The Indian Express, September 23, 2013). It follows that the ethical assumptions are different for different individuals and socio-cultural ethical assumptions may vary. For example, a child who belongs to a higher caste may think that a person from a lower caste is inferior to him or her. There are societies where males are given special privileges to take all the decisions related to female members in their family without respecting their opinions. The children who grow up in such situations define ethics accordingly. A study proves that parents' opinion and values have an impact on children's' mindset (Dweck, 2010). Most children's foundations of ethics depend on these types of situations. Besides, it has been well established that ethical development is a long,

complex, nuanced, somewhat unpredictable and multiply determined process with few guarantees (Sherblom, 2012).

The engineering students who come from different social strata and family backgrounds construct diverse ethical assumptions. In addition, techno-scientific development brings out many issues. For example, the emergence of the Internet explored the types of behavior demonstrated in cyberspace, anti-social behavior, which has led to many discussions about whether or not this activity can be inhibited by self-regulation or by the introduction of tougher laws (Krause, 2011). It changes the attitude of students and teachers. Besides, it has confused the human mind to decide the boundary between what is ethically right and what is ethically wrong. Most engineering students have unlimited free access to the Internet in their colleges and college hostels. There are students who utilize these facilities for more non-academic purposes than for academic and they rarely try to examine if whatever they are doing is ethically right or wrong. For instance, misusing technology (say hacking) for fun is unethical for some students and for others it is not. They have their own ethical justification for that. Their argument goes like this. All those who misuse technology with bad intention are unethical. "X" is not unethical, because "X" has misused the technology (say Internet) only for fun and "X" has no bad intention, so "X" is ethically right. For instance, the fun often takes in accessing the email account of juniors by some senior students and sending mails from those accounts without having the formers' permission. The word "fun" for them means anything which entertains oneself and does not matter whether this exercise of entertainment harms another person or not. They are not aware that the above-mentioned incidents are illegal and punishable crime. Technology is used as an instrument and these students are least interested to admire its real purpose. To harm others mentally or physically is unethical, through a computer or by using any other means. As stated by Dewey (2005) instruments imply ends to which they are put, purposes that are not instruments which control them, values for which tools and agencies are to be used.

These types of ethical senselessness or lack of ethical sensitivity intensifies further with the pride one attaches to the discipline of "engineering." The general system in India is that students have to clear an entrance test to get admission into an engineering college and only a very small percentage of students clear the examinations. It is assumed that high ability is required to clear the entrance tests. Thus, students who come to engineering are being considered as very intelligent when compared to students who pursue other stream of studies. Research indicates that high-ability students are superior in ethical judgment when compared to average-ability students, though ethicalness includes other components as well, such as sensitivity, motivation, and character (Tirri, 2011). Tirri offers some supporting research; it shows that gifted students hold a privileged position in the maturation of ethical thinking, because of their precious intellectual growth (Andreani & Pagnin, 1993: Karness & Brown, 1981; Termann, 1925). However, it has been seen that there are engineering students, who claim to be intelligent, demonstrate less ethical sensitivity compared to students in some other disciplines.

In India, many believe that engineering and medicine are the two most prestigious degrees. To increase or maintain their social status, parents start compelling their children to pursue either of these professions at a very early age. It has been reported that parents enroll their children into coaching centers for passing engineering and medical entrance examinations at the age of ten (Menon, 2011). Parents argue that the child may develop an interest over time. Students who show poor academic performance complain that they have enrolled for an engineering program because their parents compelled them to join the course. That is to say, they are being forced to take up an engineering program and being made to believe

that it is best for their life. It has been reported in a daily that an academic counselor says "parents want their children to become doctors and engineers without taking into consideration the aptitude of their child" (Dutta, 2013). This situation creates depression, frustration, aggression, and indifference in the children and affects their entire thinking process. This has an effect on the child's foundations of moral reasoning also. When one's own interests are not respected by the nearest and dearest (say a family member), a person creates the impression that he or she does not need to care about others' feelings. It is based on Alfred Adler's theory that psychologically secure children strive toward superiority defined in terms of success and social interest (Ansbacher & Ansbacher, 1956). Thus, in the present competitive world, they try to achieve the excellence, higher grades and best job in the market by being self-centered. One tries to modify one's ethical arguments always to justify one's own position. In that case, whatever one is doing is right for oneself. Individuals with such mental framework are less likely to make an effort to understand ethical implications of their decision-making in their profession. For them, the "right" is "approved of by me"' not that "approved of by the institute where they study or by the government." Any act which produces good consequences for the "individual doer" becomes ethically right for them.

Egoistic Pragmatism vs. Idealistic Pragmatism

Students' portrayal of engineering stems from their pragmatic ideology. The above instances illustrate the egoistic element in their pragmatism. Hammond (2013) quotes classic pragmatic maxim "Consider what effects, which might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object" (Pierce 1878, p. 135). Pragmatism explains theories or beliefs in terms of the success of their practical application. Here, the success of practical application is that doing engineering is getting into an established MNC with a high salary package. The students think that profit-making is the ultimate motive of any organization and so as a professional they have to learn the technique of profit maximization. Thus, they like to study engineering in such a way that helps them to create more profit for their organization and that will lead to their promotion or career growth and to become rich. It does not mean that students should not think about their career, but also their ethical responsibilities toward society. There are students who state that they are engaged in community welfare activities at their colleges including helping poor people or starting up NGOs or social entrepreneurships etc., only to add these in their curriculum vitae. According to them, this helps to get admission into foreign universities, especially American universities. Thus, the work they carry out in the form of social service is not a selfless service, but a "service" with selfish motives. Nonetheless, there are students who realize at a later stage that whatever they have done for society is good and they are proud that they have done that.

These conditions make the job of an ethics teacher much harder. Such teachers have a different notion about the word "engineering" and thus, a gap exists between teachers who teach ethics and students. For the teachers, engineering is using engines and technology for the development or overall well-being of society. Because the primary objective of teaching Ethics course to engineering students is to train them as ethical practitioners. Making the students aware of the various ethical issues in the engineering discipline would help to achieve this objective. The teachers believe that a person with values or a virtuous person can perform better in her profession than a virtue-less person. As virtues are not inborn, but are learned, they wish to introduce ethical situations that involve human values to the students and thereby make them virtuous persons. This

idealistic attitude of teachers is based on Froebel's concept, which is cited by Flanagan (2006, p.122) in his work that "the entire child is ever to become lies— however slightly indicated— in the child, and can be attained only through the development from within outward." Peltzman (1991) states in her paper that Froebel believed that the child should learn by doing and education should build upon the child's interests. A teacher is confused when he/she comes to know that the students' interest is not in learning values, but only in getting higher grades. An educator cannot teach ethics to an adult individual who rarely respects human values and who cares little about other fellow human beings or society in general. Teachers like to connect students to society and believe that learning ethical issues in engineering will guide them to understand the bond between engineering and society.

It has been complained that ethics teachers do not teach well or they follow a conventional method of teaching, say, lecture method. Students are not interested in ethics, because the lectures are boring. It has been widely noticed that at the higher education level, students complain that their academic performance is poor in a particular subject, because the teacher does not teach well. This can be understood in a different perspective. One who has aptitude toward any discipline tries to learn or study that subject by attending classes or studying oneself. At the higher education level, one studies oneself unlike the lower levels of education, where teachers can influence the little ones and create a certain aptitude toward a certain discipline in them. In higher education, if one has no aptitude and interest toward one subject, a teacher cannot create aptitude in him. Moreover, it is tedious and cumbersome for teachers to teach those who are uninterested in the subject. If he/she does so, then finally they end up with less job satisfaction. A student who is interested in a subject rarely blames the teacher that his academic performance is poor because the teacher or the teaching method is not good. The reason is that a person who is really interested to learn a subject tries to understand it by oneself. For him or her, it is not necessary to attend lectures by a teacher. Research (Gbadamos, 2013) shows that, attendance at seminars, but not at lectures, is significantly correlated with and a significant predictor of academic performance. Another study supports a similar view that attendance may not necessarily increase academic performance (Rodger, 2002; Joe, 1989).

Teachers follow pragmatic idealism, because they expect both moral excellence and academic excellence from the students as being a responsible professional. Here, the question arises: what is excellence? Excellence implies a deep grasp of specific body of knowledge (MacAllister, Macleod & Pirrie, 2013). Ethical excellence is deep knowledge of what is right and avoiding wrong. In other words, the students have to recognize what is right and simultaneously they have to have the courage to avoid acts that they themselves believe as wrong. Teachers know that students require both ethical and technical skills. According to the former, character development is important in the process of education. It is not true that all human beings can attain moral perfection. It is not even easy for all. Everyone can follow basic ethical principles such as not to cheat, not to kill, and not to abuse others, etc. If teachers expect the students to be ethically perfect individuals, then both groups know that it is practically impossible. The basic principle of idealism is based on connecting with others. In their professional life, team work is essential for engineers. An engineer should know how to respect his or her colleagues' viewpoints. It confirms the importance of understanding and respecting others' perspectives by the engineering students. The success of teachers depends on what extent they can communicate this ideal to their students. As stated by Plato in his The Republic, teachers have to follow a system of education that would help bring about a world in which individuals and society are moved as far as they are capable of moving toward the good. Thus, the first task of a teacher who teaches eth-

ics is to make a truce and thereby build a good rapport with his/her students. The teachers have to find suitable methods to implement their ideals of virtues or good.

Making a Truce

Here, there are two major issues: first, how to overcome the differences between teachers and students concerning the foundations of ethics and second, how ethics teachers can transmit values to those students who do not respect the discipline of engineering ethics. To unify the ethical assumptions, students have to understand their responsibilities as a professional first. As a professional, they cannot possess different ethical assumptions, like individual moral agents. The significant factor is that both teachers and students have a coordinated objective or goal. That is to say, to prepare students for a good life and get a good life respectively. This is possible only if one lives in harmony with his or her surroundings. Learning ethics helps students to realize that. It is important for the students to understand that engineering is a practice inherently tied to a variety of conflicting values. For example, efficiency is highly valued in engineering practice. But defining efficiency narrowly (as for example, the maximum of the output per unit input) may result in serious damage to the environment, the protection of which is also valued in engineering practice (Moriarty, 2003). However, studies have shown that generally, students like to be social and like to maintain quality. In her paper, Emme (2006) states that there is an urge or tendency on the part of the students to better things or higher idealism, which the writer has come to feel is a dynamic and abiding quality of student life. It points out if teachers give proper guidance, students can develop the moral character of a professional, which takes care of one's fellow beings and the environment.

The truce will be valid only if all teachers of engineering make an effort to connect their disciplines to ethics. For that, firstly teachers who teach engineering should respect ethics. Teachers who teach ethics often come from a humanities background and there are engineering students and teachers who teach engineering subjects look on those teachers with contempt. They think that only engineering is a great field and only a genius can do that and other subjects do not need a brain. Anyone can teach ethics; you do not need any intelligence for that. It is like "you simply read a book and teach." However, like any other discipline, to learn ethics one needs ethical reasoning and the ability to employ critical analysis, which is not easy to do. What students and teachers should understand is that ethics is important and everyone needs a certain level of intelligence to the subject. It depends on one's aptitude toward the subject and a broader perspective toward one's society. The failure on the part of teachers who teach core engineering discipline is that they fail to show the implications of engineering to society. The teachers rarely teach what happens if the engineers prepare a wrong design or the after-effects of these designs on the consumers or the environment. A common example engineering faculties discuss is that a smart engineer is one who designs a product (say a ceiling fan) in such a way that he uses cheap materials to manufacture the product, but it is durable throughout the warranty period. The fan stops working after two or three months of guarantee period. The consumer cannot complain if its warranty period is over. Moreover, it saves the cost of the manufacturer and creates a new customer. The customer will buy a new fan. This type of unethical practice in engineering in the long run will not bring profit for the company. Customers will realize this is cheating on the company's part, one day. Now-a-days, investors are also interested in companies that follow ethics.

SOLUTIONS AND RECOMMENDATIONS

There is a need for understanding ethics in engineering education as an inter-disciplinary subject. It is a collective effort. Ethics teachers alone cannot communicate professional responsibilities to engineering students. There is a need to integrate knowledge across courses and disciplines such as ethics and engineering. Mutual respect and high ethical standards on all teachers' part also helps the students to achieve the objective of ethical and social responsibility. In addition, teachers should understand that extreme idealism would not work. Moreover, every teacher should also possess and utilize a minimum of ethics in their profession. Asking others to follow various ideals without following them oneself is hypocritical and will not send a good message to others. The code of professional ethics for higher education teachers by University Grants Commission (UGC) has directed that as a part of their social duty, teachers have to strengthen the community's ethical and intellectual life. It also states that every teacher should see that there is no incompatibility between his precepts and practice (Tripathi, 2010).

FUTURE RESEARCH DIRECTIONS

Ethics, especially professional ethics, is an important subject for engineering education. Most engineering colleges have undertaken many new initiatives and collaborative efforts to teach ethics to their engineering students. Among them, the most admirable is incorporating ethics into the engineering curriculum and doing research to find out innovative techniques in the pedagogy to make the students more ethically sensitive. A new approach for bridging the ethical gap between teachers and students is to show the students how engineering affects the users of the products or services and how it affects the public in general. Future research strategies might use the method of connecting ethics to every discipline of engineering. That is to say, engineering teachers should teach ethical and social implications of design or manufacturing or the process related to the engineering products or services concerned. For example, the students who study laser application should also be taught the occupational safety and health hazards of laser. They should learn that individuals who manage lasers might require training for specialized electric safety-related work practice. Moreover, all teachers of engineering should be made aware of professional ethics and it is possible if all the engineering colleges adopt UGC guidelines. Engineering students can be made ethically sensitive only when they understand the ethical and social implications and consequences of their work.

CONCLUSION

In conclusion, the ethical gap can be closed if students are able to appreciate the relevance of ethics in their core engineering disciplines. That is possible only if faculties of engineering themselves take the initiative to connect the specific areas of the engineering discipline to ethics (Davis, 2006). Students' pragmatic approach is based on the view that they should achieve only practical skill or technical competence in their concerned field. In a nutshell, it is important for our engineers to take care of their fellow beings and environment. Engineering has very large consequences. Many of the ethical issues in engineering pertain to safety. Any mistake in design or production can cause harm or injury and even death. In that sense, engineering professionals' responsibility is higher than that of anyone else. It is a fact that engineers can take sound decisions if they possess good ethical character (Rottig & Heischmidt, 2007). In the endeavor of creating a responsible professional, both teachers and students should work together. It has been argued that a significant portion of students find it difficult to relate ethics to a real-

life working environment due to inexperience and hence consider "ethics" to be not so rigorous a subject resulting in poor engagement (Hasan, 2012). To solve this issue, teachers discuss various case studies, which explain how ethics relate to real-life situations. However, deliberation and more reflective thought processes are necessary for decision-making and ethical judgment (Maiese, 2013), which should be developed by the students themselves. At the higher education level, both have equal responsibility. Teachers who teach ethics do not get job satisfaction, if they are teaching students who are less interested in the course and undermine the importance of human values.

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KEY TERMS AND DEFINITIONS

Egoistic Pragmatism: Is defined as interpreting ethics on the basis of situations which is beneficial to one-self rather than others.

Engineering Ethics: Is defined as application of ethical principles in the field of engineering.

Explanatory Gap: Is defined as the variance in understanding the notion of 'ethics' by teachers and engineering students.

Idealistic Pragmatism: Focuses on interpreting 'ethics' on the basis of rules and principles.

Professional Ethics: Is defined as application of ethical principles in various professions.

Socialization: Is the process by which one understands the social norms and standards to assess what is right and what is wrong.

Chapter 10
Engineering Ethics Education:
Issues and Student Attitudes

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ABSTRACT

In this chapter, the importance of engineering ethics education in engineering programmes is discussed, involving major elements that build ethics education. Definitions and concepts of engineering ethics are introduced, along with an engineering code of ethics. Ethical education in engineering programmes is analyzed, focusing on teaching approaches and the effect of science and technological development on engineering socio-ethical issues. Survey results are presented, which illustrate students' attitudes toward engineering ethics, where it is found that students' attitudes were poor. Some strategies are suggested to improve engineering ethical education in engineering programmes.

ENGINEERING ETHICS

The Oxford Dictionary (OED, 2014) defines ethics as "(1) moral principles that govern a person's behaviour or the conducting of an activity; and (2) a branch of knowledge that deals with moral principles." Professional ethics is often confused with morality, etiquette and religion, but none of these is identical to professional ethics. Ethics philosophies originated from cultural norms, but professional ethics of any disciplines is usually filtered through religious values and set of moral ideals that are shared by people of a society (Barakat, 2011). Religion is fundamental of all ethics that exist, whereby religion is the base for personal ethics. Social and professional ethics evolved from personal ethics. "God is supreme good, so the right path of every human being is always that which leads one to honor His percepts" (Basart & Serra, 2013, p.138). Professions were developed with the aspiration to protect the life beings from every activity that has been carried out by a professional, in which to protect every life being becomes the ultimate objective of every religion. Professional ethics is a set of principles that leads a person to make correct decisions without any interference from other moral and ethical elements.

Professional ethics, and especially engineering ethics, face challenges when personal and professional ethics overlap due to unclear boundaries between these two sets of ethics. According to

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Harris *et al.* (2013), personal ethics are a set of rules or principles that covers personal commitments and how a person deals with others, whereas professional ethics are a set of rules about practicing a particular profession, including related legal issues. Practicing engineers must be able to distinguish between these two different ethics in order to make appropriate professional decisions.

According to Harris *et al.* (2013), ethics can be divided into three main sectors: (i) personal ethics, (ii) social ethics and (iii) professional ethics. Personal ethics is derived from religious belief, intuitions about right and wrong and self analysis (Laudon, 1995). For this type of ethics, the general rules are derived from religion. Social ethics arose due to the wide range of the influences and changes in the context of the society. Social ethics depends on human rights and law. Basart and Serra (2013) opined that social ethics is not found but it is developed from our interests as an individual in a society with the aspiration that every single should have equal rights and be protected by law whereas professional ethics goes beyond personal and social interest. It includes non-human being elements, sustainable development and systematic relations (Basart & Serra, 2013). Professional ethics is more common ethics as it involves the whole bio-sphere and the responsibility of a professional is extended out of the personal and societal contexts. "Professional ethics is a type of ethics that focuses on the relationship between individual professionals and their clients, colleagues and employers, or on collective social responsibility of the profession" (Herkert, 2005, p.374)

"Engineering ethics is a wide framework that brings most of non-technical aspects of the profession, including the professional, human and societal ones, into engineering practice" (Barakat, 2011, p.160). Lynch and Kline (2000) also state that "engineering ethics is a form of professional ethics, however, which requires reflection on the specific social role of engineers" (p.107). Engineering ethics covers the scope of engineering standards and how these standards should be applied. Engineering ethics also combines societal, economical and environmental factors in order to produce a set of rules that could lead an engineer to make decisions that protect the public interest, regardless of any pressure that they may encounter while serving a corporate organization. This ethics has been developed in a way that engineers will be more socially responsible in their decision-making; engineering ethics goes beyond legal and political correctness.

Engineering ethics covers a wide range of issues facing engineers. The issues are as following (Lynch & Kline, 2000):

1. Avoiding conflicts of interest.
2. Protecting secrets and confidentiality – trade secret and organization secret information.
3. Right to have different opinion.
4. Professional responsibility.
5. Obligation to protect public safety, health and welfare..

Engineering ethics combines the application of both professional standards and moral principles. Engineering ethics helps practicing engineers to recognize moral problems, and to understand what should be done when an engineer is in a dilemma. Many of these dilemmas involve making decisions to resolve conflicts between an organization and the public interest.

Unger (2000) reported a real case of a young software engineer who faced a problem with his employer. The engineer was setting up a computer interface in the intensive care unit (ICU) for a hospital in the US. The engineer found that his employer was trying hard to close the schedule gap by foregoing some important technical tests in order to meet the deadline and cut costs. The engineer argued with his employer regarding this practice, as it violated ethical standards. This eventually led the engineer to resign from the company. This scenario shows how an engineer faces problems balancing management's cost/

benefit analysis and the engineer's professional commitment to public safety.

CODE OF ETHICS

Standards of professional ethics are often formalized in a code of ethics. An engineering code of ethics describes the kind of ethical issues that might be faced by practicing engineers, and also provides a working formulation of areas for which preparation is required (Colby & Sullivan, 2008). Engineering codes establish two-way agreements (i) amongst professionals and (ii) between the public and professionals. These agreements ensure a good working environment for professionals where disputes can be solved by referring to the ethics codes. These codes are also essential in promoting the well-being of the public because they help produce socially responsible engineers who earn the trust of the public.

Codes of ethics are becoming the common standards for professional practice. Different engineering organizations have their own codes, which differ from one another due to the nature and characteristics of the organizations' different emphases and disciplines. Despite the differences in codes of ethics for each different engineering discipline, the codes do have some common attributes:

1. A primary obligation to protect the safety of human subjects, and to respect their right of informed consent.
2. An obligation to conserve natural resources and to reduce damage to the environment.
3. A constant awareness of the experimental nature of any project, imaginative forecasting of its possible side-effects, and a reasonable effort to monitor them.
4. A personal involvement in all steps of a project and an acceptance of accountability for the results of a project.
5. An obligation to protect and advance the reputation and integrity of the profession and the professionals (Barakat, 2011, p.161).

These attributes recognize the overall objectives of the engineering profession, which are to serve humankind in public safety, health, welfare and protection of the environment (OEC, 2007).

ABET – In the US, the Accreditation Board for Engineering and Technology (ABET) and in Malaysia, the Engineering Accreditation Council of Malaysia (EAC) serve as the accreditation organizations for engineering programmes in their respective countries. These accrediting organizations have adopted codes of ethics as an important part of the teaching and learning process among engineering students in both countries. Exposing undergraduates to this code of ethics will help students to handle ethics carefully, and to avoid confusing engineering ethics and common law. Undergraduates, who are the engineers of the future, are able to understand that the code of ethics can be used as a reference to solve dilemmas that they will encounter. Thus, a code of ethics is a pivotal tool for every practicing engineer all over the world.

ETHICAL EDUCATION IN ENGINEERING PROGRAMMES

Accreditation organizations require engineering programmes to teach ethics to engineering In the US, ABET engineering programme outcomes criteria f, h and j emphasize the importance of producing engineers who are able to understand and make decisions in accordance with global, economic, environmental and societal contexts (ABET, 2007). At the same time, he/she should understand the responsibilities of an engineer as part of an organization and part of society. Ethics education should prepare undergraduates to be competent engineers who are aware of socio-ethical issues and are able to react to

these issues appropriately in their conduct and decision-making.

Newberry (2004) stated that the "new paradigm for engineering education goes beyond the need to keep students at the cutting edge of technology and calls for a better balance in the various areas of engineering scholarship" (p.343). Engineering students must prepare themselves for the real challenges that they are likely to face as practicing engineers, challenges in which technological, scientific, humanistic and social issues all come together. Therefore, engineering ethics education should not only focus on code of ethics per se, but should also cover social, economic and environmental issues. This is why engineering ethics education is properly known as socio-ethical education, as the subject includes other important aspects besides ethics.

Inclusion of ethics in an engineering programme will help produce engineers who are well versed in both technical and non-technical aspects. Most importantly, these engineers will carry a spirit of social responsibility. "Socially responsible engineers" are those who hold values that are in harmony with public welfare, environment interest and also engineering inventions and development. However, the attention that is given by engineering faculties to socio-ethical subjects has been lacking compared to the attention they give to technical subjects.

Social ethical instruction in engineering education is becoming a major issue among educators. Many strategies have been attempted in order to deliver socio-ethical education effectively with technical education. In some engineering programmes, ethics has been taught as a separate course; in other programmes, ethics has been embedded in technical courses.

Embedding socio-ethical content in technical subjects yields more positive attitudes towards social responsibility among students (Li & Fu, 2012). In this way, students are able to gain more understanding of the socio-ethical issues related to the technical aspects of the subject matter. Hoover *et al*. (2009) designed a new interdisciplinary course that integrates engineering subject and socio-ethical concepts; the course aims to enhance students' knowledge and skills in dealing with socio-ethical issues related to the subject matter. In an integrated course, ethical issues related to the latest technical developments of the subject can be discussed in detail; this can prepare students to confront the challenges ahead caused by socio-ethical issues that might arise from new technical developments.

On the other hand, teaching socio-ethical subject as a separate course has its own pros and cons (Finelli *et al.,* 2012). Stand-alone socio-ethical courses can give more detailed information on ethical theories and application. Through this method, students will gain more understanding about the rules and principles of ethics and how these rules and principles can be useful to society and to public well-being (May & Luth, 2013). Despite these advantages, a stand-alone socio-ethical course can become disconnected from the technical aspects; in real engineering socio-ethical problems, technical aspects are essential in order to make the right and ethical decisions. In some universities, stand-alone socio-ethical subjects are taught by educators from non-engineering educational backgrounds (Conlon & Zandvoort, 2011). This will cause problems among the engineering students because these educators do not have sufficient knowledge and experience to teach students about applying ethical principles to engineering socio-ethical issues and problems.

New innovative approaches in teaching socio-ethical education in engineering programmes have been implemented to improve students' understanding of engineering ethics. Berne and Schummer (2005) introduced science fiction stories in engineering ethics classrooms to provide students with the necessary ethical skills and the cultural knowledge that are important in decision-making. Lathem *et al.* (2011) reported that educating engineering students on socio-ethical issues through service learning and systematic thinking could

produce positive perceptions among the engineering students. At the University of Washington, socio-ethical aspects related to nanotechnology are taught through a collaborative learning process where postgraduate students work in a small group to develop a short case study, which is related to nanotechnology ethical issues. The students post their case studies online through a dedicated website (Olmstead & Bassett, 2009).

Engineering students have also been exposed to ethics knowledge by guest lecturers. These guest lecturers are experts in engineering ethics and also practicing engineers who have important knowledge and experience to share with the students. This can expand students' ideas on socio-ethical issues related to their engineering discipline (Spitzer, 2013).

These new methods of teaching socio-ethics in engineering programmes provide a conducive environment to learn the subject effectively. Students are able to appreciate the importance of socio-ethical concepts in engineering practice. In the past, educators relied heavily on text books to teach socio-ethics, but these new approaches have changed the delivery of socio-ethical content to engineering students; now educators can add more current issues related to engineering ethics to their students' body of knowledge. These new teaching approaches offer improved methods that can help engineering educators face the challenges of teaching ethics in an environment that includes rapid technological development and increasing demands for continuous updates on socio-ethical issues in all engineering fields.

TECHNOLOGICAL DEVELOPMENT AND SOCIO-ETHICAL ISSUES

In this era of rapid science and technological development, many inventions are being introduced that affect humankind. Varma (2000) mentioned that people's expectations about science and technology development need to be matched with a proper understanding of the social and ethical consequences of that development. Scientific and technological developments offer unimagined possibilities, but some of these applications become so complex that they are not manageable. Engineers are confronted with difficult problems as many new inventions could be misused, which can cause major disasters to the human societies.

In the 21st century, compelling technologies such as genetic engineering, robotics and nanotechnology raise new socio-ethical questions. According to Harris *et al*. (2013), 21st century technologies are or will be able to self-produce, and these technologies can be easily manipulated by irresponsible individuals. In order to avoid this problem, engineers must be equipped with strong knowledge about technological changes, and also with detailed information about how these new changes will affect society and the environment. Engineers need to learn how to handle these new technologies ethically in order to avoid any unintended consequences to human beings and their environment due to any unethical activities using these new inventions.

In the case of nanotechnology, its development has strongly influenced the way we perceive the human capability to manipulate matter at the atomic and molecular levels (Nikulainen & Palmberg, 2010). Barakat (2011) noted that the media has speculated about both positive and negative sides of nanotechnology; but some of the information was exaggerated and caused fear among the public. Rapid development of a technology will often raise ethical questions among the public; engineers should anticipate those questions, and be ready to answer them. Engineers need to defend their new inventions, and to argue convincingly that these inventions could bring benefits to the society, and are harmless to the environment. Thus, engineers need to be trained in ethics so that when they build new products, systems and processes, they will succeed in protecting society, and they will benefit society and the biosphere with their inventions.

Vanderburg (2000) suggested that "there is no technology without a society and no society without biosphere" (p.5). Therefore, in order to avoid problems, engineering students have to be exposed to sufficient information on the implications of the latest science and technological developments to society and the environment. Engineering undergraduates also need to be exposed to the important values that could bring both technology and humanity together to build a better and sustainable world.

CASE STUDY: MALAYSIAN ENGINEERING STUDENTS' ATTITUDE TOWARDS SOCIO-ETHICAL ISSUES

In this case study, we carried out an investigation on Malaysian engineering students' attitudes towards socio-ethical issues related to engineering.

Engineering Accreditation Council Malaysia (2007) requires students to be educated in professional and ethical responsibility as well as in the impact of engineering solutions in a global and social context. According to Malaysian Engineering Accreditation Council regulations, all engineering faculties that offer engineering programmes should include at least one socio-ethics subject in every engineering programme, regardless of the discipline involved. This socio-ethics subject should cover societal implications, ethical considerations and economic impacts of the engineering profession in both national and international contexts.

Engineering programmes in Malaysia generally have only one subject where the ethical issues, principles and concepts are the main focus. The subject covers only the surface level of the socio-ethical concepts related to engineering. In Malaysia, generally speaking, no strong emphasis is placed on embedding socio-ethical issues into technical subjects; instead, socio-ethical education and technical education are regarded as two different entities.

Conlon in Zandvoort (2008) argued that there is concern that engineering education focuses more on employability rather than on producing future engineers who are adequately prepared for social responsibility. Zandvoort was also concerned about the knowledge and attitudes being transferred to these undergraduates for them to make decisions and act in an ethically and socially responsible way when they become engineers.

In this case study, we focused on students' attitudes and beliefs about socio-ethical issues generally, rather than the content of the subject related socio-ethical education. A survey was administered to 43 final-year engineering students of Universiti Tunku Abdul Rahman (UTAR), Malaysia. All participants were in their final semesters before graduation, and they were from several different engineering disciplines. All the respondents also went through a compulsory engineering ethics subject—Engineers in Society—which covers socio-ethical issues, environment impacts and economic implications of the engineering profession. The objective of the subject was to expose students to the history of science and technology, to issues of the impact of technology on economical development and environment, to issues of engineering in the Malaysian context, to the engineering profession, to a code of ethics and to professionalism.

The students were surveyed via a questionnaire containing statements related to ethics in engineering. The statements were adopted from Lathem *et al.* (2011) and Balakrishnan *et al.* (2013) studies, and these statements were modified according to this study's needs. In the questionnaire, a 5-point Likert-type scale (5 for Strongly Agree and 1 for Strongly Disagree) was used to rank the level of agreement and disagreement with the statements.

A total of 20 students were selected by stratified random sampling for interviews to get their point of view on (i) engineering ethics education and (ii) their roles and responsibilities as future

Table 1. Mean and standard deviation (SD) for each statement

Please indicate on a scale of 1–5; (1—strongly disagree, 2—disagree, 3—neutral, 4—agree, 5—strongly disagree)		
Statement	**Mean**	**SD**
A1: I am confident to solve engineering problems ethically	2.97	0.391
A2: I am aware of the role of engineers in today's society	3.12	0.266
A3: I am aware of the impact of engineering on economic issues	2.15	0.248
A4: I am aware of the impact of engineering on the environment	2.88	0.194
A5: I am aware of the impact of engineering on humankind	2.95	0.259
A6: I believe in the importance of ethics in every decision-making process	2.66	0.284
A7: I believe in the importance of being sensitive to the public's views in engineering design/projects	2.78	0.301
A8: I believe in the importance of sustainability issues in engineering design/projects	1.95	0.109

engineers. The students' interviews were used to support and ascertain the findings of this study.

The data were analyzed using the Statistical Package for Social Science (SPSS). The reliability value for the collected data was (Cronbach's Alpha) a = 0.824. Cronbach's alpha values indicate that the data collected for this study is reliable and acceptable. The data collected were normally distributed.

For this case study, we assessed students' attitudes towards socio-ethical issues related to engineering. Table 1 shows mean values ranging from 1.95 to 3.12 with a standard deviation from 0.109 to 0.391. The mean value scores indicated that the respondents had low mean scores in response to statements A1 through A8 in the questionnaire. Statement A8 had the lowest mean score of 1.95 in the questionnaire; this mean score indicates that awareness and knowledge about sustainability development in engineering has not been well emphasized in the engineering curriculum of the university investigated.

Sustainable development is a pivotal element and should be considered an important element in engineering subjects for the advancement and enhancement of the quality of life. In the interviews, students raised concerns about the integration of socio-ethical issues in technical subjects, which is currently not practiced in the programme. Therefore, a topic/chapter on socio-ethical implications and possible risks to humankind from the scientific/technological development of the subject matter should be included in technical subjects in order to produce future engineers who are socially, economically and environmentally aware of their roles and responsibilities. Such students would also be able to anticipate risks to humankind before they occur due to engineering advancements.

The majority of interviewees said that they had taken Engineers in Society without realizing the importance of socio-ethical issues in the engineering profession; at the same time, there was a lack of socio-ethical-related activities conducted throughout the rest of their programme of study. The students also commented on the lack of expertise amongst lecturers in teaching engineering ethics, especially pertaining to socio-ethical issues arising from the latest technology developments. This shows that the faculty/university should give more attention to learning outcomes and teaching methodologies in order to expose students to ethics and social responsibility values related to the latest technologies. At the same time, students should be instilled with sufficient attitudes and skills related to socio-ethics. More socio-ethical activities related to the students' field of study need to be offered, such as service learning, which

could develop and improve students' sense of social responsibility.

This study also showed that the students' attitudes towards socio-ethical issues related to engineering are low due to less emphasis being put forward by faculty of this study on the socio-ethical issues in the undergraduate engineering programme. We have noticed from students' responses that the engineering programme's emphasis was less on the sustainable development issues, so it was decided that faculty members need to incorporate modules that focus on sustainability. In this study, students were found to be unaware of an engineer's role and responsibilities to society at large. This is due to a socio-ethical education that is not effective enough in building students' knowledge, skills and attitudes regarding socio-ethics.

STRATEGIES TO IMPROVE SOCIO-ETHICAL EDUCATION IN ENGINEERING PROGRAMME

From the results of our case study, it is clear that the existing socio-ethical education was not achieving its objectives in producing socio-responsible engineers. Thus, some new strategies were proposed to teach socio-ethical issues in the engineering programme. The proposed strategies are as following:

1. In terms of the content: socio-ethical content could be enhanced through inclusion of the following topics:
    a. the concept of a code of ethics and its importance,
    b. proper way to use a code of ethics and
    c. current socio-ethical issues related to technological advancements and sustainability.
2. Active participations by the engineers and also by engineering professional institutions/ bodies to educate and share their knowledge and experiences with the students on socio-ethical issues are essential; they can provide detailed explanations about the code of ethics and how to use it diligently. Therefore, faculties who teach engineering ethics subject should work hand in hand with engineers and engineering professional bodies.
3. Constructive discussions on socio-ethical issues should occur in the technical subjects where educators can enlighten the students with examples and case studies of engineering ethics' dilemmas that are relevant to the technical details in that subject. Through this method, the students could enhance their understanding on the ethical issues and are able to get a better view on how to solve the issues because the ethical issues are interrelated with the technical subject. At the same time, engineering students could gain more appropriate skills in material selection and managing resource responsibly in order to build sustainable environment.
4. The sense of responsibility and positive attitude towards engineering socio-ethical issues can be instilled through activities that focus more on humanitarian assistance such as community service. Through this service, students will build themselves to be responsible engineers who can carry out their duties effectively.

CONCLUSION

Socio-ethical education in engineering education plays a pivotal role in developing socially and ethically responsible future engineers in their decision-making and conduct. This socio-ethical education moulds an engineering undergraduate to be a holistic engineer who can carry out his/her duties efficiently for the benefits of the organization, while also protecting the public interest as well as the environment.

From the case study, we found that the respondents' attitude towards socio-ethical issues related to engineering is poor. Moreover, the respondents' attitude towards sustainable development in engineering is not promising. The faculties need to improve the method of teaching of this subject using multiple approaches that can enhance students' attitude towards all the elements related to socio-ethical issues in engineering.

It is important for every engineering faculty to look again at the content, delivery method and inclusion of latest engineering development in socio-ethical subject where failure to focus on this aspect could have negative effect on the future of national economy, societal well-being and environment sustainability due to irresponsible engineering activities.

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KEY TERMS AND DEFINITIONS

Attitude: A settled way of thinking or feeling about someone or something, typically one that is reflected in a person's behavior.

Ethics: A set of moral principles, especially ones relating to or affirming a specified group, field, or form of conduct.

Professional Ethics: Type of ethics that focuses on the relationship between individual professionals and their clients, colleagues and employers, or on collective social responsibility of the profession.

Socio-Ethical: Human judgments on ideas about the ethical nature of the human community and also environment.

Social Responsible Engineer: Engineers who make decisions to protect the public interest, regardless of any pressure that they may encounter while serving a corporate organization.

Sustainable Development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Chapter 11
Teaching Engineering Ethics in the Classroom: Issues and Challenges

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ABSTRACT

Engineering students are introduced to their profession's ethical and social responsibilities along with their education and training at university. This might be the only time and place where public welfare engagement may be promoted by the institution and acknowledged by students. Their future behavior as engineers heavily depends on the understanding and commitment they may develop during this process. The purpose of this chapter is to discuss the main points related to the teaching and learning of Engineering Ethics at universities. In order to gain insight into this complex educational scene, a set of questions are formulated and explored. The discussion of these questions amounts to explain what Engineering Education consists of, how to integrate Engineering Ethics courses into the curriculum and develop instructional designs for classroom teaching, who should assume teaching responsibilities, and finally, what Engineering Ethics goals should be. For each query, the primal issues, controversies, and alternatives are discussed.

INTRODUCTION

The bottom line is that the things engineers do have consequences, both positive and negative, sometimes unintended, often widespread, and occasionally irreversible. (Augustine, 2002, p.6).

Today, Engineering Ethics (EE) is a subject included in many engineering curricula. The extension, the contents, the final goals, and the pedagogical approach to this subject still remain as open questions, but its importance in the education of the future engineers seems to be growing day by day (Rabins, 1998). For instance, the Criterion 3 (Student Outcomes) of the ABET 2010-2011 Criteria for Accrediting Engineering Programs document (ABET, 2009) requires from students both, "(f) an understanding of professional and ethical responsibility" and "(h) the broad education necessary to understand the impact of engineering solutions in

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a global, economic, environmental, and societal context." Another example, more closely related to the profession, is the National Council of Examiners for Engineering and Surveying (NCEES, http://ncees.org), which includes some questions on professional ethics in the examinations for the professional engineering license in all 50 states of the US. Also, most of the industries have set ethics training and corporate social responsibility in their policy. In some cases, it may be argued that it is just advertising or make-up looking for greater profits. Certainly, it is so, but not always. Companies have learnt that sustainable practices and fair relationships are not only good for the society and the environment, but also they can increase the reputation, productivity, and employee growth of their own businesses.

The purpose in this chapter is to discuss primal issues related to the teaching and learning of EE at universities. In order to be able to understand this complex panorama, a set of questions are formulated and examined from multiple perspectives. The answers supplied here come mainly from both philosophers and engineers who have either taught this subject somewhere in the past or have been teaching in engineering institutions. Here we presume that success requires both outlooks: theoretical and practical, reflection and experience. Further it needs to work together and share common goals. The below questions are formulated for examination.

a. Why EE education?
b. What should be the objectives of EE education?
c. What should be taught in EE?
d. Who can teach EE best?
e. Is it possible to create an impact in student's moral attitudes? Is it desirable?
f. Are there any ethical requirements for engineering students to study EE?

BACKGROUND

In the process of review of the teaching and learning in EE education something is quite clear, namely that many issues are not so clear. Certainly, this fact does not come as a surprise. Applied ethics is not a technical subject, whereas good teaching is not a mechanical, routine activity. Both operate, now and then, in dynamic situations. They are highly dependent on cultural context, personal experience, human relationships, and environment. Therefore, the fact that the object of study is not so clear means that there is no broad consensus found on the following fundamental issues. To start with, is an EE course really necessary for engineering students? If the conclusion is *yes*, then, what should be the curriculum of this course? What should be the goals of this course? How should it be taught? Is EE a unique subject that differs from other professional ethics? Moreover, things are not straight and easy because even if some consensuses are obtained, the problem still arises that engineering curricula are much overburdened and well established. Thus, it is often a real challenge to add new compulsory subjects to them.

In an interview with Derek Bo, ex-President of Harvard University (1971–1991 and 2006–2007), published in The Civic Arts Review (CAR, 1988), we may read:

CAR: Do you think the concern for ethics indicates one of those seismic shifts in public opinion that every now and again overtakes the American people?

Bok: That may well be the case. During most of the twentieth century, first artists and intellectuals, then broader segments of the society, challenged every convention, every prohibition, every regulation that cramped the human spirit or blocked its appetites and ambitions. Today a reaction has set in, born of a recognition that the public needs common standards to hold a diverse

society together, to prevent ecological disaster, to maintain confidence in government, to conserve scarce resources, to escape disease, to avoid the inhumane applications of technology.

As a first approach, it can be said——following Bok exposition——that the interest in ethics, in a general sense, often goes hand in hand with periods of crisis or threats, which implies changes and difficulties. The increase of human power resulting from the development of modern technologies during the last century has opened new possibilities, but also new risks and uncertainties due to the unpredictability and lack of control in these complex systems (Wulf, 2004). This fact is present in every branch of engineering, and occurs in many sciences (chemistry, biology, or medicine). Such a vision is consistent with the current interest for ethics in engineering and technology (Stephan, 2001; Herkert, 2002) because contemporary societies have become highly dependent on the services, works, and products that engineering and technology provide. Finally, the different forms of globalization, and the effects of overconsumption such as exploitation, contamination, environmental pollution, or resource scarcity (Woodhouse, 2001, 2003) should be taken into account.

Without any kind of doubt, scholars defend that, by virtue of their position in society, professional engineers are expected to assume an ethical code, which establishes what means today to be a responsible engineer (Skinner *et al*., 2007). What is more, this issue is not considered just a plus, but one of the key requirements for being a good engineer (Vesilind, 1999). Engineering students are introduced to their profession's moral and social responsibilities along with their education and training at university. These are the only time and place where public welfare engagement may be promoted by the institution and acknowledged by students. Their future behavior as engineers depends on the understanding and commitment they may develop during this process. At the same time, the interest in social responsibility is not in accordance with the attitude prevailing at the universities where the future engineers graduate: "[…] the way ABET's recommendations for the study of ethics has been implemented within engineering programs falls far short of the mark" (Bucciarelli, 2008, p.148); "[…] there is no positive sign let alone evidence for an assumption that the way in which universities currently prepare students in science and engineering for social responsibility is adequate or sufficient" (Zandvoort, 2013, p.1417). Researches suggest that many personal initiatives clash with faculty opposition, skepticism, or lack of interest (Newberry, 2004). Some members just believe that ethics cannot be taught at all because "it comes from inside" (Colby & Sullivan, 2008).

Once it has been decided to implement EE education, some different perspectives are possible. For instance, principles-based ethics is often set against virtues-based ethics or consequences-based ethics (Kerner, 1990), but the implications in each case are not always analyzed in an in-depth study (Bouville, 2008). Also, values education, moral reasoning, and moral choice are three different options (Gregory, 2009). Historically, personal ethics was the first scope, but today it is not enough; public safety, sustainability, social responsibility, and moral justice should not be ignored (Conlon, 2008; Heikkerö, 2008; Brauer, 2013), while the individualistic approach has been criticized (Conlon and Zandvoort, 2011; Basart & Serra, 2013). This distinction is often referred to as macro-ethics versus micro-ethics (Herkert, 2005; Son, 2008).

There are also many pedagogical approaches to the teaching of EE, and no one appears to be the most efficient. The analysis of cases is widely used, as well as the study of professional codes of ethics, ethical heuristics, service learning, and lectures on technology or moral theories (Haws, 2001; Maner, 2002; Skinner *et al*., 2007; Colby and Sullivan, 2008). Humanities reading (Olds & Miller, 1997; Sucher, 2008), role-playing (Prince, 2006), community research (Ozaktas, 2013),

meta-ethics (Haws, 2004), and problem-based learning (Sunderland, 2014) are valuable contributions developed lately. It is worth mentioning that student-inspired activities may also be rewarding (Alpay, 2013; Holsapple *et al*., 2012).

When considering the introduction of EE in an engineering curriculum, three main possibilities may be considered (Rabins, 1998; Lincourt & Johnson, 2004; Ryan & Bisson, 2011; May & Luth, 2013). First, as a stand-alone course (mandatory or elective); second, across the curriculum, embedded in some other subjects; third, by means of several external sessions included in a course or seminar. Every option offers advantages and suffers from objections. Now, when the question is who could best teach EE, the answer depends on where the emphasis is put: on engineering or on ethics. In the first case, the teacher could be an engineer, whereas in the second it could be a philosopher or a sociologist. Certainly, it seems that the ideal case occurs when the teacher has received both kinds of training (engineering and philosophy or sociology). In this section, it is also an interesting query whether the students' maturity (Clifford, 2011) or the teachers attitudes (Churchill, 1982) should satisfy some specific requirements.

When teaching EE is important to distinguish between indoctrination and professional socialization or, in other words, between preaching and teaching (Pfatteicher, 2001). Also, it is possible to distinguish between values inquiry and values transmission (Camenisch, 1986). Whatever be the choice, EE can benefit by the insights got from neighbor disciplines, particularly Science and Technology Studies (Kline, 2001; Herkert, 2008) and philosophy of technology (Son, 2008; Cooper, 2009).

REASONS

Everyone working as a professional engineer takes responsibilities that are invariably attached to their profession. The same happens to a doctor, a lawyer, or a pilot, to mention just a few examples. Society puts much confidence in the knowledge and the capacities that they have. On their part they serve society through their expertise and respect to the public trust.

The professional responsibility of an engineer comes from the effects that engineering works have on both the welfare of people and the environment. It is sufficient to notice how basic sectors like energy, communications, industry, and transport depend critically on engineers and engineering. The weight of these effects calls for an honorable behavior when considering manners, laws, and ethics. This awareness is part of an engineering education, what Vesilind (1999) calls to be a "good engineer." This responsibility is usually reflected in the profession code of ethics, these documents being the explicit commitments of the professions with the well-being of people and a sustainable relation with the environment. However, these formal declarations would not be worth the paper they are written on if engineers were not ready to defend them through their exemplary conduct. Therefore, some education in engineering ethics becomes necessary for the engineer before getting a license, and the most appropriate place for it to take place is during those years of training at the university. The intense and impactful learning takes place when engineering students adapt a particular way of understanding what engineering is and how engineers are expected to work. This implies that during the initial years of engineering, the university has the opportunity to guide students to develop and consolidate their morality.

CONTENTS

Accepting the inclusion of EE in the university curriculum for future engineers does not close the matter, it just opens it. It is so because it asks some further questions about what kind of moral

education is appropriate for engineers. What ethics framework is the best? What should its scope be?

In the least ambitious approach, it is enough to present some moral values, possibly the ones considered the most important in the profession (for instance: honesty, fairness, accountability, integrity, and pursuit of excellence). This choice is also the easiest way and has the advantage of being endorsed by the codes of ethics of many engineering professional associations. The students are expected to recognize and appreciate these values whenever they appear. Following this first level, it is possible to go for enhancing moral reasoning and moral sensitivity. This includes the capability of detecting moral conflicts and then constructing, comparing, and criticizing ethical arguments. The last option and the most difficult one is to deal with moral choice. At this point, final decisions must be reached taking into account the interplay of all the interested parts, together with the feasibility of the different options, general values and principles, circumstances and context, particular arguments, and possible consequences.

It still remains an open question whether it is advisable to present high-level ethical theories to the students in applied ethics courses (Pamental, 1991; Harris, 2009), although it seems that most scholars answer affirmatively. When this is the case in EE, the most common ethical frameworks currently used are Kantianism, utilitarianism, virtue ethics, and rights theory; however, care ethics or discourse ethics is not so often included. Many times these frameworks are presented as decision-making tools, that is to say, without justifying their validity and criticizing their shortcomings, sometimes even without naming them. One reason is recurrent, there is often no time to carry out a philosophical analysis of them. However, that does not mean that it could not be useful for the students. In any case, which frameworks are chosen (how many and why) and how they are used in the classroom analyses (as another resource or as the last criterion) makes all the difference.

Micro-ethics deals with individual behavior whereas macro-ethics deals with social responsibility and the profession. They are neither in opposition nor incompatible; they both are important and required in all fields of science and technology. Engineering activities are no longer pivoting on engineers work; due to the powerful impact of its works, engineering is now engineering in relation to both society and environment. Modern societies are now fully conscious of this strong interdependency and of what is at stake (Wulf, 2004; Son, 2008; Brauer, 2013).

METHODOLOGY

EE may be set out in a number of different contexts. Most usual resources are analysis of cases (real or made up), professional codes of ethics, ethical heuristics, and lectures on moral theories. However, it is also possible to resort to community research, humanities reading, problem-based learning, role-playing, or service learning. Again, these options do not exclude themselves. In fact, many courses include some of them in a complementary way because each one places their emphasis on some different aspects. For instance, the following can be highlighted.

Analysis of cases offers the opportunity to put abstract ideas into practice. These cases may be highly motivating for the students whenever they are related to the engineering tasks. First, the students may discover moral problems both evident and hidden and the complex set of facts, relations, responsibilities, and factors (economic, technical, political, psychological, cultural), which have an influence on the conflict. Finally, they have to suggest and weigh up several alternatives.

Professional codes of ethics reflect the professional engineers' commitment to the society. These documents clearly establish all the values, attitudes, and goals that are important, and that should always be respected and promoted. Also, they have a wide consensus and are revised and

updated according to new social concerns. Therefore, the codes condense the today moral core of engineering practice in such a way that they may help to discover the right direction to follow when things become unclear.

Ethical heuristics provide formal procedures or strategies devoted to the exploration and formulation of a final decision. These decision-making tools are presented as a well-defined set of ordered phases or tasks to follow, which are easy to understand and apply to a situation, independently of its particular characteristics. Among their merits, there is the guarantee that no essential task is forgotten or misplaced during the analysis.

Lectures on ethical theories are useful when it is important to lay some foundations of applied ethics; also, lectures on history or philosophy of technology may be appropriate when the introduction of some complementary perspectives becomes useful to enrich ethical analysis. These presentations can facilitate to the students a later reading of textbooks and more specialized literature. When these lectures are open to the contribution of the students where they may ask questions or express doubts, they may result in a very dynamic and stimulating way of introducing otherwise tiring topics.

Among the possibilities mentioned earlier (see Background), humanities reading is one of the most challenging initiatives. This is so, first because engineering students are not expected to be acquainted with this literature. Second, because this proposal may arise quite a direct opposition among them in the beginning. Certainly, they agree to work on many subjects related to mathematics and physics, but not on novels or plays. Nevertheless, through carefully chosen readings the students learn to identify moral problems, to deal with them, and to develop moral imagination; and this is just the core of what EE looks for.

The last point that needs attention in this section is what level of success is achieved. In other words: What is the students' progress in moral judgment after following EE education? Two tools are most used when moral judgment has to be measured. Both are tests, *Defining Issues Test* (DIT, DIT2) (Rest *et al*., 1974; Rest *et al*., 1999; Drake *et al*., 2005) and *Engineering and Science Issues Test* (ESIT) (Borenstein *et al*., 2010). DIT has been gathering data during the last four decades, and it is widely used due to its capacity to detect how general moral principles are applied to particular circumstances. The latter is based on it but has been designed presenting dilemmas in the science and engineering field. Provisional results obtained by an ESIT evaluation show that there is a significant improvement in moral development after ethics education in stand-alone classes. Nevertheless, a recent survey (Cech, 2014) on public welfare beliefs in US engineering students concludes the following: "student's public welfare concerns decline significantly over the course of their engineering education."

PLANNING

Where should EE be placed? Three options are possible, without excluding the more unusual possibility of integrating two of them together. Now, the main pros and cons of each option are pointed out.

First, to present it in a stand-alone compulsory course. On the one hand, this choice sends a clear message to all concerned parts: EE matters. Today, to devote a whole course to this topic in an engineering curriculum is a bold commitment yet. On the other hand, it will not easily gain wide support among academicians and administrators convinced that such a course has no place in an engineering curriculum. Also, it may be difficult to find a teacher with a strong background in both engineering and ethics.

Second, to embed it in the technical subjects of the curriculum. The pros are that EE will be recurrent along the subjects and years in the education of the students. It will appear reflected many times within several different contexts and situations.

In this way, the moral dimension of engineering may be emphasized. The cons are the commitment required from many teachers and the coordination among them. Also, it may be difficult to agree on what fraction of the courses should be devoted to moral analyses.

Third, to move it to some external sessions. This option becomes a way of sending the difficulties away from the faculty or the department, because someone else will prepare and teach the agreed sessions. This scheme may simultaneously have positive and negative consequences. On the one hand, it avoids confrontations inside the faculty but, on the other, it declares that EE is not considered an important subject as it is not cultivated at home. It seems unrealistic to expect that the students engage in a situation like this.

A new dilemma appears about the course: who should teach it? Two choices arise immediately, an engineer or a philosopher/sociologist. The possibility of two highly motivated teachers working together is usually excluded due to wage costs, but it is worth weighing up the advantages and weaknesses of interdisciplinary team teaching (Spitzer, 2013). Perhaps the ideal situation would be to take on someone with an engineering and philosophy/sociology background, but this is quite an uncommon academic profile. The teacher often appears as a result of a personal initiative, some *humanist* engineer in the faculty who is also interested in non-technical subjects like philosophy of technology or Science and Technology Studies (STS).

Finally, is it important or necessary for students to have a certain degree of maturity? These points are difficult to ascertain, but something may be said. With regard to students, and following Clifford (2011), "Among these [prejudices] are the convictions that ethics cannot be taught, that it is a personal matter, and, most pernicious, that there are no objective standards by which to adjudicate between conflicting moral claims" (p. 127). It appears impossible to become morally literate without overcoming these prejudices. Nevertheless, the profile of engineering students and the characteristics of the subjects that they study require in many cases much arduous work from the EE lecturers. Even so, this work will succeed only if the students are willing to openly question these prejudices.

PURPOSES

Some authors consider that, in EE education, it is both possible and desirable to separate knowledge (understanding) from action (being). For instance, Pfatteicher (2001) claims, "We should strive, then, to teach our students *about* ethics rather than to teach them to *be* ethical" (p. 137). Also, Abaté (2011) argues, "If we understand "teaching engineering ethics" to mean training engineers to be moral individuals, then I fear that advocates of this endeavor have set for themselves an impossible task" (p. 594). Others believe that both extremes should be avoided, namely indoctrination and value-free ethics, and propose something between them (Bishop, 1992; Camenisch, 1986). For instance, Camenisch (1986) thinks that, "[…] those areas of activity——primarily business and the professions——considered in applied ethics, and beyond them the entire enterprise of education […] are all value-laden moral undertakings. Thus, it is appropriate for applied ethics courses not only to describe the values inherent in business and professional activities, but, within limits, to advocate them" (p. 503-4). This second choice seems more appropriate, at least because society expects from engineers as professionals not only that they know what ethical behavior is, but also that they behave according to it.

EE education becomes more prominent when it is seen not as a fine complement to engineering education but as one of the core dimensions of engineering. This richer perspective has to be developed at schools and universities by some or other means, and one of the best options is to highlight a broader context for EE by showing its links with the history and philosophy of technol-

ogy (Mitcham, 1994; Harris *et al*. 2005). This is important because it allows the students to realize that technology is more than an instrument to achieve human goals, it contributes to defining a certain society, its goals and values. Therefore, engineering and engineers have to consider what kind of society they are helping to construct.

FUTURE RESEARCH DIRECTIONS

Due to its worldwide effects, it is reasonable to defend that one of the main research lines in EE should be how to extend traditional EE, based on an engineer's personal responsibility towards the broader notion of social responsibility. This last concept includes two related but different aspects: sustainability and social justice (United Nations, 2000, 2005; Brauer, 2013; Riley, 2013). Sustainability refers to the many environmental issues that concern present and future generations, whereas social justice refers to a fairer distribution of social goods. The so-called *paramount clause*, "the safety, health and welfare of the public," is widely recognized in the engineering codes of ethics because it defines the core of the engineers' responsibilities, but today it alone is not enough to face our current global challenges.

Managers and engineers, among others, are often involved together in ethical conflicts (Sauser, 2004). The perspectives, commitments, and interests are different for both, so it is not always easy to reach accords or consensus when divergences appear. Therefore, it could be beneficial to study what engineering ethics and business ethics share with the aim of establishing common ways and goals. In spite of what separate managers from engineers, their professional ethics share many responsibilities and so they could complement each other.

CONCLUSION

There are two main conclusions regarding EE education. The first one is that although EE education is formally praised in many forums, public and private institutions, the fact is that there is still much reticence and lack of commitment within universities and schools. Many valuable initiatives arise, but they do not receive significant institutional support. Therefore, it is difficult that these projects may advance and consolidate. They frequently depend on the effort and goodwill of their promoters, which are left alone with their particular odyssey. This is the situation often reflected in conferences and journal papers.

The second one is that EE education still leaves many possibilities open to exploration; there is much room for new approaches. It has been tried to show in this chapter that there is great diversity and uncertainty in several fundamental issues. Without a doubt, scholars are not short of ideas, proposals, studies, or experiences; on the contrary, during the last decades there have aroused many of them. However, they do not give good results; it seems that present conditions do not facilitate to make the most of this work. At the same time, there is an urgency to meet new social challenges, demands, and responsibilities where engineering and technology have a clear impact. Perhaps society is not ready yet to deal with these claims wisely enough, but they cannot be ignored indefinitely.

This overview began quoting Derek Bok. It seems appropriate to finish it with his last answer in the same conversation (CAR, 1988):

CAR: Would you put moral education on a par with research and professional training as an aim of the modern university?

Bok: I'll answer with one of my favorite quotations. It's from Montaigne who said: "To compose our character is our duty, not to compose books, and to win, not battles and provinces, but order and

tranquility in our own conduct. Our great and glorious masterpiece is to live appropriately."

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KEY TERMS AND DEFINITIONS

Applied Ethics: The application of ethical theories for the purpose of finding an ethical action in a given matter.

Engineering Education: The academic teaching of knowledge and principles related to the professional practice of engineering.

Engineering Ethics: Professional ethics applied to the practice of engineering.

Professional Ethics: The analysis of the personal and organizational standards of behavior expected of professionals.

Social Responsibility: The proposal that both individuals and organizations have an obligation to act to benefit society at large.

Chapter 12
Integrating Ethics into Engineering Education

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ABSTRACT

In this chapter, the authors aim to explore the necessity of teaching ethics as part of engineering education based on the gaps between learning "hard" knowledge and "soft" skills in the current educational system. They discuss why the nature of engineering practices makes it difficult to look beyond dealing with engineering design problems, identify the difference between knowledge and risk perceptions, and how to manage such tensions. They also explore the importance of developing moral responsibilities of engineers and the need to humanize technology and engineering, as technological products are not value neutral. With a focus on Problem-Based Learning (PBL), the authors examine why engineers need to incorporate ethical codes in their decision-making process and professional tasks. Finally, they discuss how to build creative learning environments that can support attaining the objectives of engineering education.

INTRODUCTION

In the book *Educating Engineers: Designing for the Future of the Field*, Sheppard and his colleagues (2009) discussed that today's engineers, like other professionals such as physicians, nurses and lawyers, have to deal with an ever-increasing complexity in their fields of work while considering changing societal needs. The explosion of new information technologies, robotics, biotechnology, and the increased blending of invention with scientific discovery are powerfully affecting everyday life in unexpected ways. For instance, information technologies are not only speeding up communication and information exchanges but also increasing the complexity in how tasks

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are carried out and how business is organized worldwide. Environmental and societal issues require local and global solutions (Feest, 2008), and engineers at work, at the center of all these developments, are frequently challenged to grapple with the ramifying consequences of such rapid innovation (Bugliarello, 2010).

Engineering as a profession has come a long way from the era of Leonardo da Vinci and others when craft and science enjoyed a scared harmony to a widening recognition beyond technologies (Beder, 1999). Every major engineering innovation, from metal making to electronics, has brought changes in society. The development and practice of engineering is affected, in turn, by significant changes in society's goals, customs and expectations (Bugliarello, 2010). This calls increasingly for engineers' moral responsibility: engineering helps to provide basic needs such as water, food, shelter and energy, and does so on the scale necessary for a society to function, but it has also contributed to the huge increase in the destructiveness of weaponry and warfare seen over the centuries. It increases inequality and the global damage that inflicted on the world's ecosystems. As an engineer, it is crucial to understand the dual nature of the profession and to be vigilant regarding the engineer's role with employers, in order to maximize the chances of positive contributions to society. In essence, this is what it means to be a socially responsible engineer (Parkinson, 2010). Some of the important attributes of professional engineers are to have commitment to high standards, appreciation of personal and ethical responsibilities, the ability to handle uncertainty and to communicate effectively (Jones, 2010). Engineers are accountable for the results of their decisions within the context of economic, political, ethical, cultural and environmental issues (Bader, 1999). To cope with the demands and complexities of decision-making processes, engineering educators have to make more efforts to integrate ethics into engineering education. As emphasized by ABET (2007), engineering graduates must have an understanding of professional and ethical responsibility, broad education necessary to understand the impact of engineering solutions in a global and social context, recognition of the need for and ability to engage in life-long learning and knowledge of contemporary issues.

However, this has been ignored to some extent because universities have traditionally concentrated on providing "hard technological knowledge" where the "soft skills" become the "appurtenant" in engineering education. For example, Newberry (2004) surveyed the motivations for thinking about and trends in teaching of ethics in engineering education in the USA. The results indicated systemic barriers that impede the integration of such instruction in the curriculum. These barriers include a lack of emotional engagement with engineering works on the part of the students, which in turn is mainly focused on the technical aspect of the curriculum. Similarly, Sheppard et al. (2009) pointed out that although engineering educators put some efforts to inculcate ethical behaviour in their professional task, they face difficulties due to (1) the institution's role in promoting ethical responsibility and (2) figuring out how to integrate ethics into the engineering program. Thus, Sheppard et al. (2009) argued that designing an undergraduate engineering program for professional practice would enhance the usability of students' knowledge as well as strengthen their understanding about engineering design and other engineering-related skills. Thus understanding ethical codes impacts on professional practices that could lead to the social and ethical dimensions of engineering.

Therefore, with the aims of educating new-century engineers, a series of pedagogical strategies have been proposed by theories and/or explored in practice, such as Cooperative Learning (Richard, Woods, Stice, & Rugarcia, 2000), Problem-Based Learning (PBL) (de Graaff & Kolmos, 2007), Project-Centered Learning, Learning in Labs (Sheppard et al., 2009) and so on. The central emphases of such strategies are not only to acquire

hard knowledge but also soft skills including leadership, critical thinking, communication skills, self-directed learning skills, hands-on experience, individual accountability and teamwork ability, etc. Out of all these strategies, PBL has been recently regarded as a potential instructional model due to its principles such as problem orientation and project work, group learning context and the shift from teaching to facilitation (de Graaff & Kolmos, 2007).

Following the above points, this chapter delineates the necessity of teaching ethics as part of engineering education. It examines the following issues.

1. Why the nature of engineering practice makes it difficult to look beyond dealing with design problems and to identify the difference between knowledge and risk perceptions and how to manage such tensions.
2. Why it is important for engineers to develop moral responsibilities and humanize engineering artefacts.
3. How PBL is a potential strategy to guide engineers to incorporate ethics in their decision-making processes and professional tasks through creative learning environments.

The chapter aims to contribute the significance of ethics teaching to engineering students and the necessity of considering engineering profession as a social and political activity.

ETHICS IN ENGINEERING PRACTICE

The Nature of Engineering Practice

The history of "engineering" as a profession, where payment is made in cash or kind of service, began with tool and weapon making over 150,000 years ago – indicating that engineering is one of the oldest professions (Marjoram, 2010). The term "engineering" derives from the word "engineer" used in the 1300s for a person who operated a military engine or machine – such as a catapult or, later, a cannon. The word "engine" in turn derives from the Latin *ingenium* for ingenuity or cleverness and invention. The term "art" and "technical" are important because engineering arranges elements in a way that may or may not appeal to human senses or emotions, and related also to the Greek *technikos* relating to art, craft, skill and practical knowledge and language regarding a mechanical or scientific subject. Prior to the development of the different fields of engineering, engineering and "technique" were originally closely connected (Marjoram & Zhong, 2010).

Traditionally, engineering is thought of as applied science – at the interface between science on the one hand and society on the other (National Academy of Engineering, 2004). Mathematics usually plays an important role as it is the language engineers' use. Engineering is concerned with the systematic application of scientific and mathematical principles towards practical ends for the benefit of people (Zhou, 2012). However, humans live in engineered economies, societies and techno-cultures; almost every area of human interest, activity and endeavour has a branch of engineering associated with it (Marjoram & Zhong, 2010). The enormous changes found in technology that engineering has brought about make profound changes in society and daily life. The most central change has been the transformation of *a linear conception* of problem analysis and problem solving that presupposed a more stable organizational and physical environment to *a network, web, or system understanding* of engineering work (Sheppard et al., 2009). There is a diverse and increasing range of areas, fields, disciplines, branches or specialization of engineering, as knowledge developed and differentiated as subjects subdivided, merged or new subjects arose (Marjoram & Zhong, 2010).

Recent studies have argued engineering practice is an example of a complex system (Sheppard et al., 2009), which underpins the point of

"engineering in context" meaning engineering activities are situated within a larger realm of human activities and culture that surrounds them at the micro, meso and macro levels (Christensen, Delahousse, & Meganck, 2009). In essence, the central activity in engineering practice is problem solving. As many engineering problems start off by being under-defined or ill-defined, the setting work is both critical and difficult (Sheppard, Colby, Macatangay, & Sullivan, 2006). However, in general, there are two typical characteristics found in problem solving: complexity and uncertainty. Complexity means many components are involved, and these components influence each other. Whereas uncertainty means not all requirements are known, not all criteria are established, the effect of a partial solution on the overall solution or on other partial solutions is not fully understood, or only emerges gradually (Zhou, 2012). Increasingly, engineering work has become a highly collaborative process. The scope, timeframes and complexity of most projects require the effort of teams of engineers – experts in some aspects of engineering practice working in coordination with other experts (Sheppard et al., 2009). The fact that engineering is a process that requires the synergy of individuals, machines (artifacts) and social organizations has driven Cooperate Social Responsibility (CSR) to move from the margins to the mainstream, from a preoccupation with public relations and philanthropy to a concern with a range of strategic issues. This has also become of critical importance to policy-makers and practitioners (Mattehews, 2010).

Thus, in the working place, the knowledge that engineers draw on is increasingly dynamic and complex. The types of knowledge that engineers bring to bear in their work are wide-ranging: engineers must not only stay informed about new and emerging technologies but must also be aware of knowledge skills from other domain. As summarized by Sheppard et al. (2006), there are at least three types of knowledge needed to solve complex problems in engineering: (a) knowledge that can be "put into play" (know how, what, why and when), (b) knowledge that is continually changing (expanding, evolving) and (c) knowledge that ranges from science-based to contextual, from tacit to procedural. In addition, a series of constraints relating to ethical issues on the solutions that those engineers have to consider when the knowledge is applied, such as technical function, economic feasibility and resource considerations (Zhou, 2012).

The Affordances of Risk: Tensions between Knowledge and Risk Perceptions

Boholm & Corvellec (2010) propose a relational theory of risk that is culturally situated and should be therefore ascribed with value. They argue that risk is "a product of situated cognition that establishes a causal and contingent relationship" between object and value systems (p.186). Taking such a position means that we can describe risk as something that comes with certain affordances. Affordances explain the relational qualities of things and refer in the context of risk perception to the social structures, values and belief systems that shape how individuals perceive risk. What one group perceives as risk may not be perceived as such by others, also because the landscape of risk is differently assessed, understood and interpreted by different members of society. Ingold (2011), referring to Gibson's (1978) work about affordances, highlights this relationship between values and meanings and how this is differently interpreted between individuals and groups.

Governments, industry and the individuals representing those groups are understood to have a responsibility to protect societies from risks and harmful experiences, and this means that what is perceived as risk needs to be identified and mapped and carefully and responsibly communicated. If risk is as Boholm (2003, pp. 161) writes "a statistical probability of an outcome in combination with severity of the effect construed as a 'cost'

that could be estimated in terms of money, deaths or cases of ill health" then someone's objective and particularly subjective assessment of risk shapes greatly how risk is perceived, negotiated and contested. This is so because people make decisions that are not idealized or isolated but disturbed by sometimes irrational and contradictory knowledge. For instance, a person may veto the building of new windmills because it could disturb the flight path of birds or change the aesthetics of a landscape or perhaps even pose a risk of blade failure with associated risks of falling debris. However, such a position may change if that person owns the windmill. Perceived risk versus perceived benefits can shape how decisions are made about risk factors.

Tensions between knowledge and risk perception arise when risk is conceptualized as something that can be calculated, is known and probable because at times there are different degrees of unknown or uncertain factors. Geertz (1983) described this tension also as a result of being either experience-far or experience-near. Another aspect is that knowledge systems differ among everyday knowledge, scientific knowledge and what is communicated through different media outlets. These systems are socially defined and constructed and define how the different communities within different disciplines see and verify the world. This means that risk is differently perceived by different people and is shaped by belief systems, values and social structures (Boholm & Corvellec, 2010).

SOCIAL RESPONSIBILITY OF ENGINEERS

Engineers can face a number of challenges especially when their work is concerned with technology that can have transformational consequences. They have to make ethical decisions that guide how they respond and take responsibility for the actions they take. However, engineers do not work in social vacuums but are part of institutional or organizational structures that shape and define policies, codes and procedures of their work practices. This means that the organizational cultures where engineers work have professional norms and standards of behaviour. Andrews (2006) argues that engineers need to accept technological citizenship. Citizenship involves having rights and also responsibilities. Andrews (2006) writes that this means engineers need to go beyond following normative rules and act professionally responsible as a "technically informed" citizen (p. 46) to use their expertise to make deliberate stands on technological decisions that affect all. Andrews conveys that engineers' technical literacy means they need to act on their obligation to help organizations address the challenges that arise from new or changing science and technology conditions. Grudzinski-Hall, Jellison, Stewart-Gambino & Weisman (2007) point out that becoming engineers requires sets of competencies that include global perspectives because "sustainable engineering solutions, the ultimate goal of engineering professionals, cannot be developed without consideration of the cultural, political, and economic climate in which they will be implemented" (p. 6).

In a resent thematic issue of *Science and Engineering Ethics* journal, on teaching social responsibility to students in science and engineering, Zandvoort, Børsen, Deneke & Bird (2013) describe that engineers act socially responsible if their activities, actions and decisions satisfy certain ethical principles, and socially irresponsible if (they do) not satisfy those principles. This definition is aligning with Koen's (2003) definition of ethical decision-making and acting of engineers. There is, however, a difference found between Koen (2003) and Zandvoort et al. (2013), i.e., in the case of former, it is assumed that consensus can be established within the engineering profession and in society on the basis of what these principles are and how they should be interpreted.

We adapt Bauman's (1993) proposal in *Postmodern Ethics* to suggest that it is up to the individual engineer in the concrete situation to choose,

interpret and justify which ethical principles and norms are followed in the activities, actions and decisions that are being made. What is important are individual reflections and attempts to ethically justify activities, actions and decisions to the surroundings that hold primacy in engineering ethics. Ethical behaviour is often ambivalent because the same activities, actions or decisions are supported by some ethical principles while violating others. Ethical reasoning has to do with ethical judgement where one decides on, balances or transcends conflicting ethical principles and norms (Børsen, 2013).

To give an example, we might consider that chlorinated hydrocarbon dichlorodiphenyl trichloroethane (DDT) is a very effective insecticide, and according to The World Health Organization (WHO), has saved 25 million lives, and most likely also increased crop yields (Eriksen, 2002). Indeed the chemical engineers who contributed to the mass-production of DDT could ethically justify their actions with reference to the expected utility of that insecticide. However, such an ethical judgement would be far too simplistic and misleading. With the massive use of DDT followed unforeseen consequences and environmental risks, as the compound accumulated in the food chain, and eventually threatened biodiversity and public health. Although it is reasonable to assume that the engineers could not have been expected to foresee these exact consequences, they could have been expected not to commit hubris. This ethical concern materialized in the early 1990s into the precautionary principle. The case of DDT presented an ethical dilemma between the expected utility and precaution. The difficulty is how to balance those two conflicting ethical principles. Similar dilemmas could be identified in respect to other technologies, though the involved conflicting norms might very well be different.

Turning the attention to the main theme of this chapter, ethics education in engineering, one can ask how universities can teach engineering students to identify and balance ethical norms appropriate to the specific technologies they specialize. This is the topic of the next section.

TEACHING ETHICS TO ENGINEERS BY ADAPTING PBL

Development of PBL in Engineering Education

The literature indicated that the term Problem-Based Learning (PBL) was originally coined by Don Woods, based on his work with Chemistry students in McMaster's University in Canada. However, the popularity and subsequent worldwide spread of PBL is mostly linked to the introduction of this educational method at the medical school of McMaster University (De Graaff & Kolmos, 2007). Theoretically, the constructive learning principle emphasizes that learning is an active process in which students actively construct or reconstruct their knowledge networks. Learning is also a process of creating meaning and building personal interpretations of the world based on individual experiences and interactions (Zhou, Kolmos & Nielsen, 2012). Practically, students' learning centres on complex problems that do not have a single answer or solving real-life projects. Students work in collaborative groups to identify what they need to learn in order to solve the problems. The teacher acts to facilitate the learning process rather than to provide knowledge (Hmelo-Silver, 2004).

The literature also discusses multiple skills students can improve through a PBL approach. For example, students have opportunities to construct extensive and flexible knowledge, develop effective problem-solving skills, become effective collaborators and develop self-directed learning skills (Hmelo-Silver, 2004) and social responsibility (de Graaff & Kolmos, 2007). Due to the effectiveness of multiple skills in students' learning, PBL has been employed in many universities around this world (Zhou et al., 2012). According to the

earlier numbers provided by the literature (Samford University, 2000), there were more than 100 undergraduate institutions with faculty members using PBL. Those institutions involve universities in areas of United States, Australia, Belgium, Canada, Denmark, the Netherlands, Hong Kong, Sweden and United Kingdom, etc. Most of those institutions have covered the educational fields of engineering. However, recent work (de Graaff & Kolmos, 2007) indicates PBL is an instructional approach that has drawn more and more attention to engineering education and appears to be of growing interest (Kolmos, Dahms, & Du, 2010). In spite of the diversity of application of PBL around the world, "student-centred learning" has been regarded as the core principle (Savery, 2006; Zhou et al., 2012). Moreover, a mixed-mode approach combining Problem-Based Learning and Project-Based Learning has also been proposed as the potential successful strategy to be used in the future (Mills & Treagust, 2003; de Graaff & Kolmos, 2007).

"Bildung" as a Learning Objective

The concept of "Bildung" appears in the 19th century in Germany, and has ever since played an important role in German and Scandinavian education and pedagogy. Different understandings of "Bildung" generate different ideals regarding what characterizes the "well-educated" individual by the formation of individual "taste": the ability to distinguish epistemological, ethical and aesthetical, between true/false, good/bad, beautiful/hideous (Børsen, 2012).

"Bildung" rests on the assumption that human beings have the possibility to transcend their instincts and immediate needs and instead be guided by their rationality. It calls the individual to transcend him or her in the direction of humanity. This point is about recognizing oneself as a true human individual being that is part of a greater whole. Different concepts of "Bildung" interpret human essence differently.

"Bildung" includes individual's access to human essence that requires learning through examples in order to recognize the differences between true/false, good/bad and beautiful/hideous. This trait of "Bildung" points to an important question: who or what draws the distinctions between, for example, good and bad in concrete cases. One possible answer is it is up to the individual to form "taste" along with providing justification for the drawn distinctions.

To translate "Bildung" into an engineering education context, a few words must be said about the epistemological, ethical and aesthetical distinctions. Epistemologically it is important for an engineer to be able to identify relevant and trustworthy knowledge to accomplish engineering tasks. Ethically it is important to make ethical judgements (Borsen, 2012, cf. section 3.2). Finally, the engineer must also include aesthetical concerns in designed solutions (Christensen, Henriksen & Kolmos, 2006).

Using a "Bildung" perspective, the learning objectives of engineering education cannot be reduced to the reproduction of knowledge and methods in a specific area of engineering. An engineer should also be able to transcend that knowledge and those methods by seeing them in a greater holistic, ethical and aesthetical perspective. A "Bildung" perspective also suggests that the study of concrete examples and with that, the associated problems, is an important aspect to make significant learning experiences.

Building Creative Learning Environment by PBL

As mentioned earlier, "Bildung" is a salient concept in this chapter. It is not determined by separate academic disciplines, but by life as a whole and the individual's share in this whole. This notion of the whole person and the whole life demands an interdisciplinary approach, one that goes way beyond the content for that day to the development of the person as a professional,

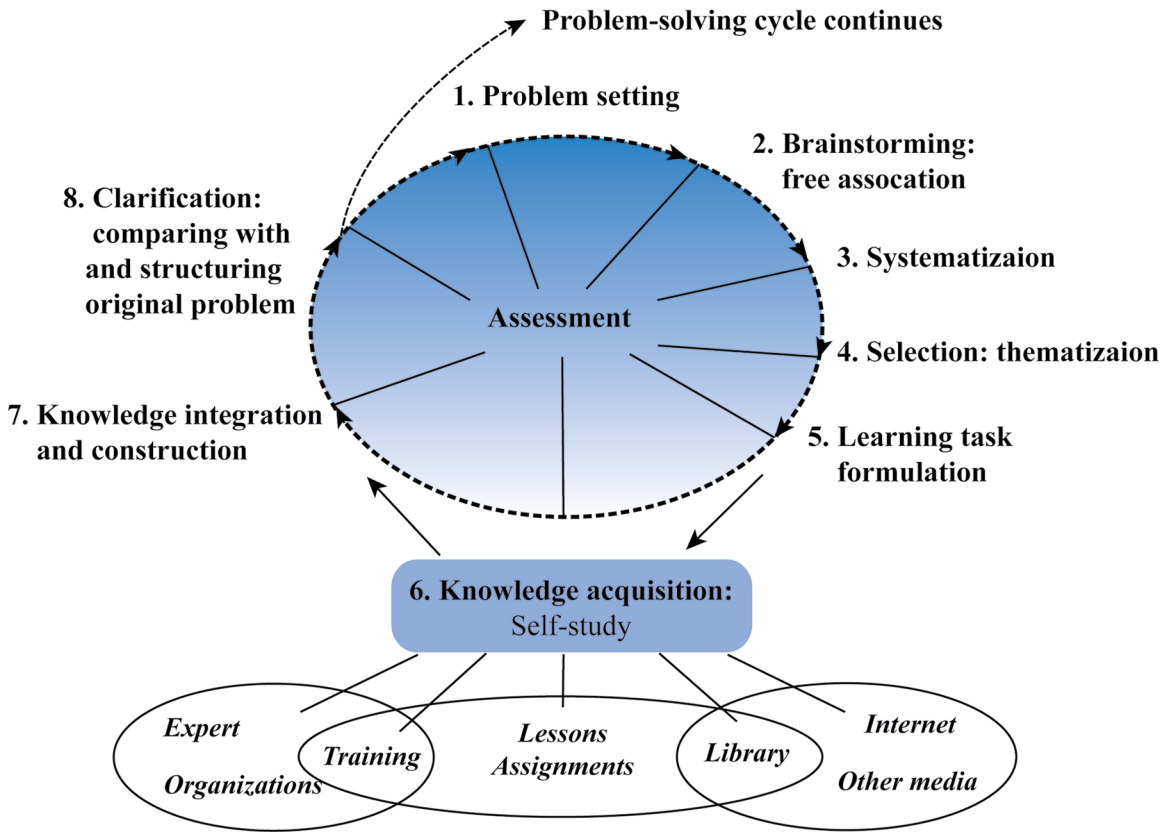
a member of society, a parent and an employer/ supervisor (Ballie, Bo, Newstetter, & Radcliffe, 2011). An expanded view of engineering education affords helping students become whole persons and aligns with the socio-cognitive perspective or situational theory of learning, as what the theories of PBL have focused.

In practice, as an innovative model, PBL also has been argued as a way of building creative learning environments that help students to reach the learning objectives effectively (Hmelo-Silver, 2004). In general, creativity involves the ability to offer new perspectives, generate novel and meaningful ideas, raise new questions and come up with solutions to ill-defined problems (Sternberg & Lubart, 1999). So a problem triggers the context for engagement, curiosity, inquiry and a quest to address a real-world concern (Tan, Teo, & Chye, 2009). The student learning process in PBL may be structured in different ways (de Graaff & Kolmos, 2007). Poikela, Vuoskoski & Kärnä (2009) provide a model of PBL learning cycle that also demonstrates a tutorial process (Figure 1).

In this cycle, the PBL process begins with students working towards a shared understanding of the problem presented to them. They then brainstorm ideas about the content area related to the problem using their existing knowledge and prior experiences. Similar types of ideas are grouped into named categories. The most important and actual problem areas among the named categories are determined. The first tutorial session is then held to decide on the learning tasks to undertake and the goals to achieve. Following the tutorial, students engage in information search and self-study, working both individually and in pairs or in small groups depending on the learning tasks and goals as well as the strategy deemed most appropriate for seeking information. The second tutorial is the time for applying the new knowledge acquired, to tackle the learning tasks and to reconstruct the problem in a new way. New and in-depth knowledge is synthesized and integrated to provide a basis for deeper learning. Participants clarify and reflect on the whole problem-solving process in the light of the new knowledge. Assessment is part of every single phase of the process. It is necessary to close the tutorial with feedback about students' own learning, their information-seeking behaviour, their problem-solving skills and the group processes so that improvements can be made (Poikela et al., 2009). Such a cycle develops a type of learning environment that produces students who are self-confident in their social roles within a group, willing to take risk in the public social arena of the classroom and willingly collaborate with others to interpret and develop meaning from challenging problems (Porath & Jordan, 2009).

Therefore, the tutor coaches the group by monitoring the group process and helping the students to identify the knowledge that is needed to resolve the problem (Poikela et al, 2009). As "student-centred learning" is the core philosophy of PBL (Savery, 2006; Zhou et al., 2012), tutors are experts, able to model good strategies for learning and thinking, rather than experts in the content itself. They are responsible both for moving the students through the various stages of PBL and for monitoring the group process. This monitoring assures that all students are involved and encourages them both to externalize their own thinking and to comment on each other's thinking (Hmelo-Silver, 2004). However, situations caused by the ritual behaviour that can be barriers to creative learning environment should be avoided in PBL. For example, sometimes students do not activate their prior knowledge, do not decide for themselves what is relevant for their learning or cannot discuss the subject matter studied with one another (Dolmans, Wolfhagen, van der Vleuten, & Wijnen, 2001). This means educators need to engage in meaningful inquiry and form general theories. They must be aware of the conceptual landscape of their classes, crafting the form of instruction in consideration of students' knowledge and group dynamic (Porath & Jordan, 2009). They must also have a general theory of how

Figure 1. Problem-based learning cycle



learning environment and pedagogy can support deep understanding of the curriculum and nurture professional responsibility in their students. These aspects of teaching represent both the art and the craft of engineering education.

CONCLUSION

Pedagogical approaches in engineering education need to take into account the increasing challenges and opportunities that engineers have to deal with when they face the complexities, uncertainties and vulnerabilities of engineering practices. Addressing questions of ethical dimensions is common in engineering because the work of engineers has a direct impact on public health and safety, and influences directions in business development and politics. This means that engineering ethics is not simply about ethical reflections on technical appliances but is more concerned with the ability of engineers reflecting ethically upon their work. The expression "engineering ethics" is thus concerned with the human relationship with technologies. Modern engineers have great responsibilities because of the dramatic consequences of their designed artefacts, which can include not only harm to individuals, but also, due to widespread technological practices and uptake of technological products, dozens, hundreds, or thousands of individuals may be affected (Didier, 2010).

Being able to make decisions that are based on ethical judgement and reflections on the implications of engineering work calls for engineering education that goes beyond the need to keep students at the cutting edge of technology. Students

need to learn what it means to think about risks and what it means to develop technological citizenship. The concept of "Bildung" may provide a fruitful entry because it entails holistic, ethical and aesthetical perspectives and this could support preparing engineering students for a complex world where technological, scientific, humanistic and social issues are all entangled. Teaching methods that support such aims include equipping becoming engineers with the ethical thinking tools they need to consider how content may be integrated into engineering curricula. Creative learning environments may support achieving such ambitious learning goals. This chapter suggested Problem-Based Learning (PBL) with its learning cycles as an example to achieve such learning outcomes. This also implies that engineering faculties will need to explore new ways to enrich their existing teaching practices to impart quality and holistic engineering education.

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KEY TERMS AND DEFINITIONS

Bildung: "Bildung" is a German word that translates into English as cultivation of the individual. A "well-cultivated" person has an ability to distinguish true from false, good from bad and beautiful from hideous. Often educational activities are justified with reference to a certain "Bildung" ideal, e.g. the educational activities enable students to make epistemological, ethical and aesthetical distinctions.

Creativity: Etymologically speaking, the term "creativity" means to generate new and useful ideas. The field of creativity was practically started from psychological studies. Today the field has seen an explosion of interest: creativity has been discussed much by the theories such as psychology, social psychology, cultural psychology, social culture and even philosophy.

Engineering Education: Engineering education is the institutional activity to prepare students for the engineering profession. It includes teaching students and preparing them to practice engineering.

Ethics: Ethics is a philosophical discipline that reflects on what is right and wrong behaviour. Ethics is related to ethical judgement, which is the ability to decide what is right and wrong in concrete, specific, contextualized situations. In this chapter, we address engineering ethics that refers to ethics applied to engineering. Engineering ethics reflects on, discusses and estimates what is right and wrong behaviour in engineering.

Problem-Based Learning (PBL): As an innovative educational model, Problem-Based Learning (PBL) has been widely used in diverse disciplines and cultures throughout the world. In PBL, students' learning centres on complex problems that do not have a single answer or solving real-life projects. Students work in collaborative groups to identify what they need to learn in order to solve the problems. The teacher acts to facilitate the learning process rather than to provide knowledge. So "student-centred learning" is the core philosophy of PBL.

Social Responsibility: An engineer is socially responsible when she is held accountable for her actions and for the social effects of her actions. Often "social" is used as a proxy for "social, societal, environmental, and ethical," and thereby social responsibility is linked to ethics. In this chapter,

we define an engineer is socially responsible for her activities, actions and decisions.

Chapter 13
Ethics in Design:
Teaching Engineering Ethics

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ABSTRACT

This chapter addresses how engineers can incorporate an understanding of human beings into their technological innovations as well as some risks, responsibilities, and social values involved in technological design. It also addresses how best to teach Engineering Ethics. In short, the chapter analyzes Engineering Ethics from a philosophical and educational perspective. The objectives of this chapter are to discuss ethical theories and their significance to Engineering Ethics and relevant and significant case studies of international and national import for future technological designs. Further, the importance of including social and moral values in the engineering design process and the advantages of abiding by the professional ethics code in Mechanical Engineering are also discussed. At the end, the chapter discusses the best way to teach an Engineering Ethics course.

A GOOD AND USABLE DEFINITION OF "ETHICS"

The embodiment of those values that the person or organization feels are important …, and spell our proper conduct and appropriate action –Merriam Webster[1]

How can engineers incorporate professional ethics into their practice to succeed at engineering? First they must straighten out their definition of Professional Ethics.

At first glance, Webster's definition of "Ethics" seems innocently correct. It is not. This first glance issue of what "Ethics" means signals a central difficulty within professional ethics. It also shows how much Ethics needs the humanities. Many a hard-nosed engineer disdains the *belles lettres* as superfluous. But, quite simply those who fail to see the glaring fault in Webster's definition have failed to read very carefully. Reading connects with thinking; so those who miss-define Ethics fail to think very carefully as well.

For, Ethics is not what a person or organization feels is important. Should we care what Charles Manson, mastermind behind a number of heinous murders, thought was ethically important? He was a person after all despite his efforts to become the

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contrary. Nor should we care what Enron—an infamous and failed organization—thought was important for anything other than tracing the history of a disease. While they raised banners touting truth and integrity in their company parking lot and publicly lauded their financial stock and social utility, Enron executives underhandedly sold their personal stock from a sinking ship they abandoned.

This bad definition is hardly the simple province of laymen, if one can call lexicographers "laymen." More importantly, professionals in the field of Professional Ethics (hence, Engineering Ethics) also fall prey to it. Witness then a full article bedeviled by this mistaken view of ethics. O.C. Ferrell (2005), author of a book on Business Ethics, reminds one in the bureaucratic and vague language of business: "Organizational ethics initiatives have not been effectively implemented by many corporations, and there is still much debate concerning the usefulness of such initiatives in preventing ethical and legal misconduct" (p. 3). It is almost laughable to think that ethics has anything to do with business initiatives—as if this nondescript phrase "business initiative" is supposed to mean anything. How is such an ethics "initiative" to be "implemented?"

Ferrell (2005) tries his best to propose a framework that can be effectively "integrate[d]" into the business school curricula. Ferrell eschews "personal moral development and character" dependent as it is on the lottery of personal interests and upbringing. Neither do "ethics initiatives … arise inherently from corporate culture," nor does "hiring ethical employees" "limit unethical behavior." Only "proactive leadership" that provides "employees from diverse backgrounds" with "a common understanding of what is defined as ethical behavior through formal training" will create "an ethical organizational climate" (p. 3). In addition, he seems to know "how ethical decisions are made"(p. 4).

Ferrell is not alone. Recently, Magun-Jackson (2004) assumed a Kohlbergian approach to Engineering Ethics education. Rather she wrote a five page article for Science and Engineering Ethics describing a Kohlbergian approach and one that is related to it (that of Reimer et al., 1983). She provides no arguments, and certainly no considered objections. Many individuals think that arguments are not needed in Professional Ethics. What is ethical is clear; Ethics is whatever management wants.

However, arguments and attempts to answer objections are crucial to a field that is a branch of philosophy. Incredibly, one finds this kind of non-argumentative, oblivious, hand-waving pretty much everywhere in the literature on Engineering Ethics education. This is sad, not to mention counterproductive to the idea of trying to teach students how to think ethically. To think ethically, students must think and produce supporting arguments; and they do not see their professors often doing that. Many professors fail to demonstrate ethical thinking so scrupulously that one wonders if they even know how to do it. These really are deep philosophical issues—no less than what it is to be virtuous!

Virtue and how to make ethical decisions have stymied philosophers for centuries. To take a very old example, Plato, despite earnest efforts to transform both the citizens of Athens and indeed the government of the Italian Penninsula of Syracuse—a place he happened to visit once or twice—failed quite simply to show "how ethical decisions are made." Plato's friend and devoted student, Dion, invited him to one of the first recorded episodes of taming the tyrant. Meanwhile, Plato who detested tyrants almost as much as he detested democracies offended Dionysius, the ruler, so badly that he (Plato) ended up being sold as an Athenian slave at Aegina.

This, of course, improves upon the fate of his mentor, Socrates, who, in Christ-like fashion, was put to death by the very public he sought to show "how ethical decisions are made." Fortunately, Anniceris of Cyrene rescued Plato (Reale & Caton, 1990, p. 394). Had Anniceris not intervened, Plato would never have founded the Academy and

the world would have been bereft of such great works on virtue such as the inconclusive Meno.

One would think the historical legacies of Socrates and Plato a lesson to anyone who would so easily show the world "how ethical decisions are made." However, some new thinkers believe that they have an ace in the hole that Plato did not. What, they ask, are all our scientific and cultural improvements since Plato good for if not to delineate right from wrong? In short, Ferrell has a basis in psychology, that most understood and relevant science for ethical teaching. He has Lawrence Kohlberg.

Lawrence Kohlberg (1927–1987) was an American psychologist best known for founding a new field of psychology called the theory of moral development. His work has been used and endorsed without much reservation by numerous professional ethicists such as Ferrell, Magun-Jackson, and Weber:

Relying on an expanded view of leadership and the moral reasoning framework developed by Lawrence Kohlberg, this study explores the moral reasoning of the chief executive officers at the 11 largest automobile manufacturers in the world. … The CEOs' moral reasoning is compared to other managers' moral reasoning, and the moral reasoning exhibited within the CEO group is analyzed for differences due to regional location. (Weber, 2010, p. 167)

Weber believes he can neatly assess the "moral reasoning" of CEOs at "the 11 largest automobile manufacturers in the world" by simply applying Kohlberg!

In brief, Kohlberg theorized that individuals act on conventional and post-conventional levels. A conventional moral reasoner concerns herself with punishments and rewards, with so-called selfish interests, or the role she plays within an organization. In contrast, a rule-follower follows either company or societal norms. Someone at the post-conventional level looks beyond "self-interest" and "beyond society to consider a universal scope of analysis."

Johnson (2012) gives the standard criticism of Kohlbergian psychological analysis. "It draws heavily on Rawls' theory of justice and makes deontological ethics superior to other ethical perspectives (p. 91)." Deontological Ethics, or ethics based on rights, duties, or obligations is only one kind of ethics. There are also theories based on self-interest, social utility, or virtue ethics (to name a few). Many ethical perspectives rival rule-following. There is, for example, the famous care ethics, that has thrown male-dominated insistence on principles over relationships on its head. Carol Gilligan's critique of Kohlberg runs thus:

A major criticism of Kohlberg's theory is that virtually all of the research on which it is based used only men as subjects. … Women fare less well according to Kohlberg's levels of moral development because they tend to view moral dilemmas differently. … Women are more likely to adopt a care perspective that "views people in terms of their connectedness with others and emphasizes interpersonal communication, relationships with others, and concern for others (Santrock, 2008, p. 362)." (Zastrow & Kirst-Ashman, 2010, p. 304)

In addition, a number of psychologists have also argued, "individuals can engage in many ways of thinking about a problem, regardless of age" (Johnson, 2012, p. 91; Gibbs, 2003).

Weber and to a large extent Ferrell simply offer Kohlberg's analysis as a fait accompli without much if any consideration of or response to objections. This type of hand-me-down ethics dispensed with a dictatorial and supposedly authoritative wave is a horrible way to teach ethics to Engineering students who are supposed to think for themselves.

Ferrell is certainly more careful than Magun-Jackson (2004). He asks:

Can moral philosophy and moral development predict ethical behavior in businesses and other organizations? Ferrell, Fraedrich, & Ferrell (2008) found that only 15 percent of a sample of businesspersons [how big a sample?] maintained that same moral philosophy across both work and non-work ethical decision-making situations [how was this assessed?].

Nevertheless, most experts agree that a person's stage of moral development and personal moral philosophy play a role in how values and actions are shaped in the workplace. (Ferrell, 2005, p. 10)

Ferrell asks whether Kohlberg's theory of moral development can predict ethical behavior. In answering his own question, he insists that he can discern what "same moral philosophy" means across both work and non-work situations. This is like trying to find a needle in two haystacks without knowing what a needle looks like as he never defines what a moral philosophy is (any attitude on morality?). Then he appeals to so-called experts and uses the deflating weasel words "play a role" when he says that Kohlberg's stages of moral development "play a role" in "how values and actions are shaped in the workplace."

On the one hand, he undercuts his own reasoning as to how he can tell people "how ethical decisions are made," by saying that people are not consistent or that Kohlberg only "play[s] a role." On the other, he gives scant reason for one to believe that he can tell people "how ethical decisions are made" by not appealing to traditional theories of philosophical ethics. In sum, Ferrell, Fraedrich, & Ferrell (2008) hardly encourage students to question either their sample size or their method of assessment, let alone the validity of the whole Kohlbergian corpus.

I really think that more textbooks within Professional Ethics, Engineering Ethics especially, actually discourage ethical thinking in this way than encourage it. This is all tied to the textbook's bad definition of ethics, which defines ethics as what someone else—the society, organization, or firm—thinks is ethical, rather than to what the student has been able to glean based on the arguments. Authors really proceed as if arguments are superfluous and that everything is so cut and dry that it may be laid out in a textbook for passive students to absorb.

Ethics needs arguments because it is a branch of philosophy, and it is a branch of philosophy because it is "basically an open-ended, reflective and critical intellectual activity. It is essentially problematic and controversial" (Ladd & Johnson, 1991, p. 130). If these statements amount to circularity, then so be it. Moreover, ethics must be self-directed:

Even if substantial agreement could be reached on ethical principles and they could be set out in a code [or Ferrell's framework], the attempt to impose such principles on others in the guise of ethics contradicts the notion of ethics itself, which presumes that persons are autonomous moral agents. (Ladd & Johnson, 1991, p. 131)

Prisoners behave the way their guards make them behave. Mere good behavior does not make prisoners (who we may suppose guilty for the sake of argument) ethical. Morality can only be discerned from what one does when no one is watching. Notoriously, it is difficult to discern anything when no one is watching, and so people have invented conscience, perhaps God and the afterlife, to watch over them and make them good. Still, the point is that ethics must start and end with individual internal decision-making and not the organization or some nebulous "framework" applied from without to control behavior.

Consider the Christian canon. In the famous Sermon on the Mount, Jesus did not rest satisfied that his followers were simply following the "letter of the law" such as "thou shalt not commit adultery." He appealed to the "spirit of the law," which seems to say in this case that even looking at a woman with "lust in one's eye" was already

committing adultery with her in "one's heart." Whatever one thinks of Christianity, or God, surely the reader admits a difference between mere acting and acting with right intention.

In fact, Kohlberg would have strongly agreed with the requirement of self-determinate ethics as such self-determination is a requirement of his third and "best" stage of moral development. Paradoxically, Ferrell actually uses Kohlberg to insist that students remain at Kohlberg's second, rule following, stage of moral development. As long as they remain in the second stage, they may effectively use the framework he provides rather than transcend to his third stage where they may dispense with the framework in favor of their own minds. No ready rubric or framework can be applied at the third stage. The third stage is where all such rubrics are critiqued.

Personally, I think Kohlberg's stages of moral development so much nonsense and for reasons that I have seen no one else point out. (Not that what Kohlberg did was nonsense, but applying it to ethics is nonsense.) Stages of moral development are nonsense because it seems to me that the most immoral individuals would score highly on the scales of moral development. Kohlberg asserted that at the post-conventional level:

- **Stage Five:** Social contract. People at this stage of development focus on doing what is best for society as a whole and respecting individual rights. Civil disobedience would be endorsed by people in both stages of post-conventional morality.
- **Stage Six:** Universal principles. At this stage, individuals are focused on upholding principles of universal justice, fairness, and ethics. They believe in the democratic process, but also endorse disobeying unjust laws (Reimer, Paolitto, & Hersh, 1983).

Take Hitler (2010) for example. He thought wholeheartedly that he was doing what was best for his society and that by trying to take back (as he thought) Austria he was thoroughly respecting the rights of his citizens. He certainly endorsed civil disobedience via the brown-shirts until he, of course, became the "legitimate" authority. He certainly upheld principles of universal justice, fairness and ethics. He argues in the second paragraph of *Mein Kampf* that only after reunification with Austria "can the moral right arise, from the need of the people to acquire foreign territory" (p. 13).

It will be replied that Hitler did not actually respect anyone's rights concerning the invasion of Austria or any of the ensuing aftermath of World War II. Yes, I quite agree. But that is not the point. The point is that according to the Kohlbergian post-conventional scale of moral development he was acting at a highly developed stage of morality! To say otherwise, while accepting the Kohlbergian schema is to infuse morality into the schema, whereas one is supposed to derive morality from it. Kohlberg's scale is supposed to elicit when someone is or is not moral. The scale is not supposed to confirm deeply held convictions from other sources! If morality comes from other sources, then Kohlberg's theory does not determine moral development so much as it confirms someone's prejudices. Hence it is these ethical prejudgments that are of real interest for moral development.

In short, Hitler scores high on Kohlberg's stages of moral development, although one would like to say he was not very morally developed. According to this *reductio (ad absurdum)* of Kohlbergian stages upon which Hitler would be highly morally developed, something is wrong with Kohlberg's stages. Quite simply, I think Kohlberg offers stages of cognitive development, not moral development and we can say that Hitler was smart and immoral.

Ethics is the study of the theories of what is good or bad, right or wrong in human conduct. It is essentially argumentative, has to be individually assessed, cannot be assessed through a rubric or framework, and cannot be identified with an organization's written or unwritten assumptions.

A DISCUSSION OF THE VALUES FOUND WITHIN THE ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS) CODE OF ETHICS

How can engineers incorporate professional ethics into their practice to succeed at engineering? Secondly, one must understand the use and limitations of values expressed in so-called Codes of Ethics.

Codes of Engineering Ethics developed in the first place in the United States in the late 1800s. Schuyler S. Wheeler, then President of the American Institute of Electrical Engineers (AIEE), addressed his engineering society so rousingly that they voted to embody his ideas in a code. "After much debate and many revisions, the AIEE Board of Directors adopted a code in March, 1912. The AIEE Code was adopted (with minor amendments) by the American Society of Mechanical Engineers (ASME) in 1914" (Davis, 1998, p. 45).

"In 1816, the engineering profession scarcely existed in America … Canal and railroad construction generated not only the demand for engineers, but, in large measure the supply as well" (Layton & Johnson, 1991, p. 46). The demand for engineers in the United States rose with industry, which increasingly required more and more college training. No one knows exactly what Wheeler told his fellow AIEE members, but commentators would have one believe that engineers at this early date were already concerned with "the 'high character and integrity' engineers needed to serve the interests of others committed to them …" (Davis, 1998, p. 45). They already had altruistic motives to serve the public good and benefit humanity.

I find, to the contrary that they have been and always will be concerned with self-interest above all. Of course, self-interest can be thoroughly compatible with public interest as I have thoroughly argued elsewhere (Stieb, 2006). However, the present point is to say that engineers were more concerned with gaining autonomy from business interests than anything else. They still are. According to, perhaps, the best account available—sociologist Edwin Layton's Revolt of the Engineers—"Perhaps the most invariant demand by all professions is for autonomy. The classic argument is that outsiders are unable to judge or control professional work, since it involves esoteric knowledge they do not understand" (Layton, 1991, p. 48).

So called socially responsible demands such as those to protect the beleaguered environment have come to dominate. However, these would wind themselves into codes much later (for example, the nascent NSPE requirement to "adhere to the principles of sustainable development") (Code of Ethics: 2014). Sustainability is a laudable if nebulous and perhaps impracticable requirement. The reach of technology, as they say, has exceeded humanity's grasp of the environment's plight. The difficulty lies in trying to convince engineers that their individual interests coincide with the public's or the environment's interest and that they, as individuals, should do something for collective interest as for themselves. It is difficult to motivate someone to sacrifice for the anomalous good of others, but even more difficult to convince him that the sacrifice conduces to his own personal good.

Despite such thorny issues, engineers must look to the values of engineers who wrote and designed Codes of Ethics. A designing engineer must ordinarily proceed according to the expectations of her profession. However, there are many exceptions such as building gas chambers that can be spelled out, at least in part, by just war theory (Katz, 2011; Fichtelberg, 2006). These exceptions show that at the end of the day the engineer, like the rest of us, must also proceed according to the content of her own mind and her ultimate assessment of the philosophical arguments. On the one hand, one must not scoff at societal expectations. Engineers can and should use values presented in such "Codes of Ethics" as a template for their designs. On the other hand, these codes evolve over time, and the values therein are controversial.

Advancement of human welfare or rather how to advance human welfare is controversial whether whoever placed this in the code believes so or not. Ultimately, for practical purposes, one must look at his design and ask "Does this express honesty, competence, professionalism and respect?

Here is the ACM code in brief:

CODE OF ETHICS OF ENGINEERS

The Fundamental Principles

Engineers uphold and advance the integrity, honor, and dignity of the engineering profession by:

1. Using their knowledge and skill for the enhancement of human welfare;
2. Being honest and impartial, and serving with fidelity their clients (including their employers) and the public; and
3. Striving to increase the competence and prestige of the engineering profession.

The Fundamental Canons:

1. Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in the areas of their competence; they shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest.
5. Engineers shall respect the proprietary information and intellectual property rights of others, including charitable organizations and professional societies in the engineering field.
6. Engineers shall associate only with reputable persons or organizations.
7. Engineers shall issue public statements only in an objective and truthful manner and shall avoid any conduct that brings discredit upon the profession.
8. Engineers shall consider environmental impact and sustainable development in the performance of their professional duties.
9. Engineers shall not seek ethical sanction against another engineer unless there is good reason to do so under the relevant codes, policies and procedures governing that engineer's ethical conduct.
10. Engineers who are members of the society shall endeavor to abide by the constitution, by-laws and policies of the society, and they shall disclose knowledge of any matter involving another member's alleged violation of this Code of Ethics or the Society's Conflicts of Interest Policy.

No doubt, these principles and canons express values. Some raise little debate such as honesty, competence, faithfulness, professionalism, respect. Others rankle, such as enhancing or holding paramount public welfare, striving to increase the prestige of the profession (why?), continuing professional development (how much?).

For example, I have argued that no one really knows what benefits humanity (Stieb, 2007)—everyone has a theory. Fried chicken provides a cheap source of food at a serious cost to our morality to animals and the plaque in our arteries. Nuclear power provides a relatively low cost and abundant fuel source, at a serious cost in containment facilities and quite possibly the environment.

Of course, the engineer must examine her own values, not the ASME's. Quite simply, one does

not look to the ASME code for an examination of one's own values. She looks to see what society expects of her. Hence, it should be called a Code of Societal Expectations or some such.

In fact, there are several insuperable arguments against such things being called "Codes of Ethics" in any sense relevant to the word "ethics." These arguments include the following (mostly deriving from Ladd & Johnson(1991)):

1. Ethics is open ended.
2. Ethics must be self-directed.
3. Ethics cannot be confused with law or "microethics."

First, ethics resembles psychology in this way. Many psychological theories purport to explain what makes a sound mind. Some of these theories are Freudian, Jungian, or Eriksonian—thousands or more of such theories may contend. Yet, one would not think of developing a Code of Psychology. Let the reader Type "Code of Psychology" into a google search (or the reader's favorite search engine) and he or she will find next to nothing. Type in "Code of Ethics" and entries will inundate the reader. No one would think of definitively saying what constitutes a sound mind and enforcing such requirements (without argument—mind you) on others. Yet, in engineering, only in rare cases does one even know who wrote his or her society's Code of Ethics. Even fewer authors give reasons expecting explanations to suffice in ethics!

I have already alluded to the idea that ethics must be self-directed. Self-direction is the idea that doing the thinking for someone or forcing him to behave does not make him ethical. When queried concerning some serious safety issue, many organizations respond, if they respond at all, by referring the questioner to something else—a Code of Ethics. This is simply a governing document expressing the opinions sans deliberation that corporate power structure allows to be heard. Meanwhile, Engineering Ethics concerns an organization's ethics, not its compliance.

As I said, one does not look to a Code of Ethics for an examination of her own values; she looks to see what society expects of her. Not too long ago, J. F. Lozano offered that he could split the difference. He wrote an interesting piece for Science and Engineering Ethics in which he argued that he could get around the criticism of ethics' external imposition in his creation of a Code of Ethics for the Industrial Engineers of Valencia, Spain. In a proper Code of Ethics, argues Lozano, engineers do not have values thrust upon them; they find their values within the code.

Finding rather than cowering under external values marks the difference between what Lozano (2006) calls the "compliance" approach and the "integrity" approach. The "Compliance approach … aims to establish a system of incentives and punishments to ensure that people comply with norms. … [T]he integrity approach … seeks voluntary commitment to shared values" (p. 247). The compliance approach is rather "carrot and stick"—one gets a reward for good behavior and a demerit for bad. Of course, the "carrot and stick" approach has nothing to do with actual ethics. Ethics is based on individually accepted, internalized values. Lozano reports that a Code of Ethics that utilizes the integrity approach can mirror an individual engineer's values. An Engineer beleaguered by an ethical decision rather than feeling forced by the iron hand of law or code, will find support for his deep-seated convictions.

The integrity approach seems to try to capture the experience of going to church (synagogue, ashram, or what have you). When young, parents force the budding acolyte to attend. Later, if she persists, the religious person finds her own values expressed in and by the religious institution, and not only goes willingly but also drags her own children. Of course, all too often, these values are the result of socialization and are not derived autonomously as in Kantian ethics. Lozano means those cases where one discovers her values through socialization instead of because of it.

Lozano (2006) offers a nice try, probably the best possible. Still, the idea that one's values can be effectively expressed in a Code of Ethics written by unknown and mute others ultimately amounts to nonsense, and it doesn't take long to see why. When Lozano details his procedure for developing the Spanish Code of Ethics, he relates:

Two types of methodology were used to achieve the objective[s]: Desk research and interview. Firstly, a detailed study was done of the Association's documents: … and a search was done on similar documents in other professional collectives and ethical codes in engineering associations worldwide. … Secondly, in-depth interviews were held with people with long professional careers and recognized prestige in different spheres of engineering work … At this stage of research, 10 people, chosen by sector of activity and years of experience, were each interviewed for almost two hours. The interview had a three part structure:

1. The first part focused on discovering the interviewees' general ideas on ethical issues and their impact on the profession …

2. The second part … focused on identifying the ethical problems they perceived in the profession. …

3. In the third part of the interview, they were invited to make concrete proposals … (p. 251)

If one wants to write a Code of Ethics that expresses the collective values of engineers, it makes sense to ask a rather large and random sample size of engineers what their values are. The nonsense creeps in when one has to select, as one inevitably has to do. First, one has to select the engineers to be interviewed. This one will provide a good interview; that one will not. How can one be sure that the selection criteria by which to select candidates for interviewing do not already impose ethical values? Undoubtedly the criteria already do! The interviewees are not chosen randomly; they are chosen by "years of experience." Choosing interviewees on the basis of years of experience seems quite correct to me (I agree with valuing experience), but notice the choice of whom to interview already inserts at least value into the answers one will receive in the interview! Who knows how many values one imposes all the while trying to be fair and scientific?

Lozano basically pre-determines what he will find (confirms his own values) rather than discovering what engineers themselves value in other ways:

1. "The most common and serious ethical problems where chosen" (how?)
2. "60 people were expected to participate" but only "only 25 took part" (is this a large enough sample size?) "Although it is true that the number of people involved was smaller than expected, a positive feature is the fact that the people who did participate had brilliant professional careers and credibility …" (Lozano, 2006, p. 252).
3. The degree of involvement and participation from association members was less than expected. … [and] the professionals lacked ethical training [meaning] … that their contributions were not as relevant as they might have been."

One must select "the most common and serious ethical problems" and discard, apparently, those less common and/or less serious. First, I am not sure why. Less common ethical problems can still be serious and important. Really, the only thing dictating this selection seems to be the Code's economy. It has to be short or no one will read it. However, ease of reading hardly seems an ethical criterion for selection.

Second, it seems irrelevant that the 25 people who participated had "brilliant professional careers and credibility." So did the folks at Enron before the company's collapse. Moreover, discerning who

has a "brilliant" professional career and credibility means inserting values once again where one is supposed to discover them. "Of course we must pick the most ethical people to find out what to put into a Code of Ethics!" one might say. Yes, how? Isn't the way one picks such people better than the Code one attempts to produce?

Third, Lozano throws out some of the answers of the selected 25, because they do not reflect enough ethical training. In other words, they do not say (or perhaps value) what Lozano values and expects them to say. This selection criterion really is nonsense; it amounts to throwing out counterexamples to one's expectations.

There remains no way to impose ethics from outside without remaining dictatorial and biased. Even if one tries not to impose ethics but derive it from observation and careful study one inevitably imposes because such a study must select participants, and decide what answers/behaviors are relevant. One must already have in mind the values that she wants to put into a code in order to discern that her interviewees are even expressing values.

A Discussion of How These Values Apply to the Space Shuttle Challenger, and Citycorp Tower as Well as Student Senior Design Projects Current at Drexel University (Philadelphia, USA).

How can engineers incorporate professional ethics into their practice to succeed at engineering? Engineers must learn how to apply the values expressed in their professional codes, but also how to critique those values and formulate their own.

Engineering students face many challenges. One can assist students by familiarizing them with their branch of engineering's Code of Ethics. One can also present case studies. The Space Shuttle Challenger and the City-Corp tower remain two of the most oft-used in Mechanical Engineering. Professors and texts usually tightly wrap the Challenger case into the idea that engineers must fight a managerial structure that is only out to make money even at the compromise of safety: "Am I the only one who wants to fly? Take off your engineering hat and put on your management hat":

> Lund's first response was to repeat his objections [to takeoff]. But then Mason said something that made him think again. Mason asked him to think like a manager rather than an engineer. (The exact words seem to have been, "Take off your engineering hat and put on you management hat.") Lund did and changed his mind. The next morning the shuttle exploded during lift-off, killing all aboard. An O-ring had failed. (Davis, 1991)

In fact, Davis (2014) titles this article (and an entire book (1998)) "Thinking Like an Engineer" presumably to differentiate clearly cost and corner cutting "management" thinking from "thinking like an engineer." Thinking like an engineer means prioritizing quality and safety over money.

I do not fault Davis, who has done more for engineering ethics than anyone I can think of, nor do I fault an abundant concern for quality and safety. I just think this idea that management will save money by cutting corners, although often correct, too quick an assessment in the Challenger case. It not only does a disservice to management—in this case officials at Morton Thiokol and NASA—it also does a disservice to the ethical analysis of case studies. Engineers come away misunderstanding their ethical relationship with management because they have, once again, substituted a ready rubric—a case study—for their own considered judgment. Worse, they have not delved very deeply into the case study.

Maybe Davis is right. There does seem to be some evidence that NASA and Morton Thiokol officials were not only highly motivated to cut corners (U.S. President Reagan was visiting, Thiokol's contract was up for bid, there were many previous scrubbed launches), but that they did cut corners. They missed the fact that rubber O-ring material hardens and fails to seal sufficiently at cold temperatures such as the astonishingly low 18

degrees recorded at Cape Canaveral that morning. Boisjoly of Morton Thiokol clearly and accurately reported this data and was summarily dismissed!

Or, did he? It is simply unbelievable that officials at Morton Thiokol or NASA would recommend launch if any single one of them saw the prospect of disaster. Even if only concerned with business, seven dead astronauts and blown-up space shuttle hardly make money. The Challenger disaster seems rather to be an organizational foul-up, with almost no one getting the whole story. Each individual up the chain of command received bits and pieces. The Online Ethics Center for Science and Engineering illustrates this politicizing:

NASA once again wanted the seal task force team to soften the urgency of the O-ring problem. If the word leaked that there existed a major malfunction in the solid rocket booster, Congress would likely lose even more faith in the Shuttle program. No cold weather launches were scheduled for the near future. (Shuresh, & Raghavan, 2006)

Textbooks often present case studies as cut and dry. Yet, most modern, complex, events resist the clear heroes and villains the textbooks are avid to find. There are only fallible human beings facing tough prospects. In fact, the industry demoted and blackballed the wrong person, Boisjoly, demonstrating the complex parade of organizational malfunction that surrounds whistleblowers. I find Boisjoly pretty heroic, but one cannot stop there. Questions arise all along the way about how he possibly could have resisted the demands of his superiors (Online Ethics Center).

The CityCorp Tower is another typical trumped up case. No doubt William LeMessurier deserves to be lauded for doing the right thing when he went back to weld joints that were supposed to be welded but instead had been bolted. The CityCorp tower, as most engineers know, presents a unique design with a skyscraper situated over a church with braces and tuned "mass dampeners" on the sides to prevent toppling or swaying. The apocryphal and trumped up story is that a student asked LeMessurier about quartering winds and (Martin & Schinzinger, 1996), when in reality a contractor for the job finally informed LeMessurier that the building was not built to spec (Whitbeck, 2006).

LeMessurier is supposed by nearly every presentation to exhibit the value of professionalism. However, as I wrote a few years ago:

LeMessurier's story is surely one of professionalism. But, it is far from the perfect hypothetical or textbook case LeMessurier's inability to make sure the New York contractors built the tower as designed and his subterfuge in hiding repair work mar an unequivocal label of professional behavior. Critics can plausibly find fault with any engineer and LeMessurier's faults are as glaring as his professionalism. (Stieb, 2011)

I was a bit unfair to LeMessurier. I have since learned that LeMessurier did inform the proper New York authorities. They asked LeMessurier to keep knowledge of the repair work from the buildings residents and the public. Nevertheless, it seems impossible to be 100% professional 100% of the time, a fact that textbooks elide in their zeal to make everything black and white.

Senior Mechanical Engineering students at Drexel University (Philadelphia, USA) are currently designing among other things tools to assist farmers in Bo Klua, Thailand. Professor Alex Moseson, an Assistant Teaching Professor in the Mechanical Engineering Department at Drexel, and a former student of mine, asked me to lecture his senior design students on Ethics. I happily obliged. I learned that Alex and the Drexel "Thai Harvest" team planned to introduce a time and labor saving technology—a "rice planter" to the farmers in rural Thailand. Professor Moseson won the International Humanitarian Short-Video Contest at the IEEE 2012 Global Humanitarian Technology Conference for his video "Technology Seeding which the reader can view at https://www.youtube.com/watch?v=uIxxgch6qrA&feat

ure=youtu.be. Drexel Thai Harvest's rice planter abundantly exhibits the values intended by the ASME code of ethics, including sustainability and service to humanity.

I also note the Senior Design student's interest in developing unmanned vehicles. One student discussed with me the ethical implications of entering an unmanned flier into a contest in the UK. (Sorry the name of the contest escapes me, apparently the UK holds a lot of these contests.) She was particularly concerned that the contest lacked safety protocols. After all, one must insure safety when flying a person (unfortunately a man because of upper-body strength requirements) at high altitudes. I suggested she ask the ASME to write some requirements, perhaps with her help. Every engineer, novice or expert, student or professor, has or will design structures with enormous ethical implications. Each must understand the good and bad of codes and case studies without allowing such ready rubrics to think for them.

One can only design ethically and incorporate professional ethics into practice in order to succeed at engineering if she can follow the philosophical arguments wherever they lead, and if she can apply philosophical ethical theories. The demand of student agency contradicts one of the most outrageous proposals for teaching Engineering Ethics that I have ever heard. David Haws (2006), an engineer at Boise State University (Ohio) and a professor of Engineering Ethics, writes in a fairly recent paper on teaching, "The course facilitator needs to be an engineer, and needs to approach the dilemma and the primary writings as a novice (like the student) rather than as an expert (as someone with a Ph.D. in philosophy, or a lifetime exposure to ethical discourse)" (p. 366).

Haws believes that only a novice in ethics (an engineer unencumbered by philosophical ethics) can approach the subject as a novice. At the same time, I doubt that he would ask a novice in Thermodynamics or Chemistry (someone unencumbered by knowledge of those subjects) to teach those courses! Why the double standard? One can approach the philosophical material as a novice without actually being one!

Ironically, Haws' bad argument for why the Engineering Ethics Professor should be simply an engineer and not also a philosopher (one could be both) shows exactly why the professor must be at least a philosopher. Philosophers rarely make such bad arguments.

Finally, one last rubric. Davis (1998) once again has argued that "in practice, …, moral theory will seldom, if ever, be useful (or at least, useful enough)" to students and practitioners (p. 1). Without rehearsing his considerable arguments, let me just cite Davis' "list to [sic] guidelines to help students or practitioners think through specific ethical problems" (Davis, 2009, p. 73), which seems very popular over the Internet:

- **Harm Test:** Does this option do less harm than any alternative?
- **Publicity Test:** Would I want my choice of this option published in the newspaper?
- **Defensibility Test:** Could I defend my choice of this option before a Congressional committee, a committee of my peers, or my parents?
- **Reversibility Test:** Would I still think the choice of this option good if I were one of those adversely affected by it?
- **Virtue Test:** What would I become if I chose this option often?
- **Professional Test:** What might my profession's ethics committee say about this option?
- **Colleague Test:** What do my colleagues say when I describe my problem and suggest this option as my solution?
- **Organization Test:** What does the organization's ethics officer or legal counsel say about this option?

These guidelines can be handy. However, the only good argument for reducing ethics to the ethics of one's profession or to a list of guidelines

is that such reductions "are drawn directly from common sense" (Davis, 2009, p. 69) and that they can be easily applied. Davis says "yes" to both: "students can apply them with reasonable accuracy almost as soon as they have read them because they have in fact already been applying them more or less …" (2009, p. 69).

However, with any non-trivial case concerning ethics, one typically does not know whether, a solution does less harm than alternatives (they may all cause harm). Politically, one does not usually want her choices published regardless, as these can be spun just about any way. Second, one must often choose between alternative goods with some attached evil. Third, one might persuade a law court without making much sense. Fourth, one may not want to be affected personally by a decision, and not want to be affected by not making a decision (fired perhaps or demoted) as well. Sometimes whoever is affected by the decision will change it; most of the time decisions must be made anyway. Fifth, one may not like who his job has made him but still decide to keep it; alternatively, one might like who he is but still make bad decisions. Sixth, one should really not judge one's work by the opinion of envious colleagues. Consult colleagues, but do not accept their judgment as final.

Such reductions will not do "pretty much everything teaching moral theory is supposed to do in a practical ethics course" (Davis, 1998, p. 6). In fact, critiquing where and how these criteria fail (when they do) does more to teach ethics than the criteria themselves. As Kant & Ellington (1981) pointed out, one must act out of respect (or understanding) of the moral law and not merely in accordance with it. As Ladd & Johnson (1991) wrote, "the attempt to impose such principles on others in the guise of ethics contradicts the notion of ethics itself, which presumes that persons are autonomous moral agents" (p. 131).

Most of the professionals at Morton Thiokol and NASA expected Robert Boisjoly to drop the issue concerning the affect of cold temperatures on rubber o-rings that led to the explosion of the space shuttle Challenger. In this case, the so-called professionals dismissed the naysayer because they thought they knew better. William LeMessurier may have been morally required to assert his own personal ethics over the standards of the building commission in New York. The examples of engineers who must step up and put personal ethics above so-called professional ethics can be multiplied interminably.

Surely, the practical dividends of teaching ethics do not readily show themselves. Ethics is not a branch of Accounting. Acting more ethically or being more ethical differs greatly from making better practical decisions in one's life. In ethics, one must not simply follow the law; one must understand the intention behind it.

In sum, a responsible class in Engineering Ethics must assist students in developing the critical thinking skills and independent spirit and initiative necessary to question the existing "professional ethics." More realistically, Engineering Ethics tries to reduce the number of engineers who have to contravene authority, while increasing the number of individuals who are able to do so.

I have maintained throughout this chapter that ethics is the study of the theories of what is good or bad, right or wrong within human conduct—theories such as Kantian ethics or virtue ethics—and cannot be identified with any of these theories. This is why I do not take a Kantian, or utilitarian or some such position. I take a pluralistic position, which says that depending on the situation some or perhaps many of these theories can be applied. Moral arguments provide a bedrock from which not anything goes. Essentially, one must be able to weigh the reasons one side or another offers for the position it takes. That may not sound like much; but it is a lot and not easy to teach.

Authors who do not understand this take shortcuts. They develop frameworks of ethics or schemas of moral development which amount to nonsense. In addition, they develop Codes of Ethics that have equivocal, but at least some use.

Following Codes of Ethics such as the ASME code is good if not unassailable practice. Codes have many problems, some that make it necessary to override the code. When to override the code, for example, is where ethics comes in once again, retrieved from the pigeon hole that code writers seem to want to put it in.

So, indeed, much teaching of ethics is needed. But, the right kind. "Ethics" must be properly understood and the bad moves weeded out. I hope this chapter has contributed something to these two worthy goals.

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KEY WORDS AND DEFINITIONS

ASME: American Society of Mechanical Engineers. A non-profit engineering society facilitating discussion and knowledge sharing.

Codes of Ethics: Articles adopted by (here) engineering organizations that attempt to spell out right and wrong ethical conduct.

Design: The engineering design process offers a plan of specific steps to instantiate technology in order to solve some felt need or problem.

Moral Stages: The theory that moral reasoning is not only the basis of ethical behavior but that it goes through successive stages of development and improvement.

ENDNOTES

[1] Although no longer locatable, numerous reputable pdfs, PowerPoints and other documents for ethics training attribute this quote to Webster all over the Internet.

Section 3

Practice/Execution

Chapter 14
Widening the Industrial Competence Base:
Integrating Ethics into Engineering Education

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ABSTRACT

Amidst the macroeconomic, social, and industrial trends altering the industrial operating environment, calls have been made to shift attention from specialized but narrow technical content of engineering education to a broader competence base that better accommodates societal demands. This chapter focuses on the micro-level ethical conduct that materializes in face-to-face interaction in engineering teams. The chapter serves three aims: first, it defines the key concepts employed in the discussion. Second, it offers an account of the worth and impacts of investments in emotive skills in the engineering world. Finally, it describes a pedagogic experiment in incorporating ethics into engineering degree studies at Aalto University, Finland. The ultimate objective is to propose a teaching practice that would turn the currently marginal attempts to include ethical topics in engineers' syllabi into a mainstream mindset and philosophy that dictates decisions and drives conduct in future engineering communities.

INTRODUCTION

In the contemporary society, ethics has slowly morphed into a substance matter of its own right, bridging the gap between engineering education and industrial reality. Social legitimization no longer serves as a mere marketing argument but as a requirement pervading the operations of all engineering sectors and promoting profitability, access to resources and chances of survival (Surroca et al., 2013). Besides societal trends causing a push toward engineers' wider social understanding and responsibility, industrial crises such as those of Enron and WorldCom (Welch & Ordonez, 2014) have drawn public and legislative attention to corporate governance and ethics issues. This has created a significantly more constrained regulatory operating environment than ever before, forcing organizations to acquire a social license needed to operate in their community (Huang, 2010). As an

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incentive, the supposed positive link of socially responsible operations with the bottom line has strengthened the business case for ethics (Smith et al., 2009).

Further, incidents of worker dishonesty, theft, and fraud have exploded research on employee behavioral ethics (Welsh & Ordonez, 2014). Due to these trends, calls have been made to shift focus from specialized but narrow technical content of engineering education to a broader competence base, one that would perhaps prepare engineers as full-fledged working-life professionals. This should not be regarded as a mechanical response to external demands, rather as a natural evolution of the engineering profession to accommodate societal changes (Didier & Derouet, 2013).

Such accommodation materializes on two levels. On the micro-level, individual engineers are expected to demonstrate morality, autonomy, responsibility, empathy, critical thinking and self-regulation in their decisions and conduct. On the macro-level, engineering as a profession is to collectively build a society that meets the requirements of the economy, ecology, and ethics (Korhonen-Yrjänheikki, 2011; Bolanakis et al., 2010). Instead of representing merely themselves or their own organizations, post-modern engineers are beginning to perceive their role as global problem-solving citizens (Lappalainen, 2011; Didier et Derouet, 2013).

With increasing consensus, these traditionally humanistic concerns are gaining ground among engineering educators and yet the institutional atmosphere in some technical universities still conceives these themes as second class. The shift in education foci is further hindered by many engineering students being indifferent to and ignorant of non-engineering topics. Other practical barriers include lack of expertise in social topics among teaching faculty, together with non-existent related pedagogy (Boni & Berjano, 2009).

To respond to these calls and to fill the related pedagogical gaps, this chapter focuses on the micro-level ethical conduct that materializes in face-to-face interaction in engineering teams and between individual engineers. Such an approach necessitates discussion about self-regulation, empathy, and social skills, popularized as emotional intelligence (EI). The aims of the chapter are three-fold. First, to invite those who are uninformed about emotive competences into our discussion, I begin with a definition of each key concept employed in the discussion. Second, as motivation, the chapter continues with an account of the worth and impacts of investments in socio-emotive skills in the engineering world. The final section describes a pedagogic experiment in integrating ethics into an engineering degree course at Aalto University, Finland. The ultimate objective of this chapter is to propose a teaching practice that would turn the currently marginal attempts to include social and ethical topics in engineers' syllabi into a mainstream mindset and philosophy that dictates decisions and drives conduct in future engineering communities.

Societal Mega-Trends Pressing for Ethical Thinking and Action

As an unwanted by-product of the human capacity for accelerating productivity, postmodern individuals growingly gather goods and material to bolster their feeling of prosperity. The induced ecological problems related to air, water, and soil degradation challenge industries to redesign their manufacturing processes in pursuit of production technologies that consume less energy. In addition to environmental concerns, today's way of life and reckless use of natural resources for hastened manufacturing elicit questionable social and intellectual tendencies in consumers, thereby inducing mental and societal problems (Filipkowski, 2011). Resultatively, the discussion about ethics is colored by concepts ranging wide from sustainability, ecological footprint, greenness, water footprint, diversity management and human equality to social licensing, moral reasoning, social footprint,

and professional ethics (Korhonen-Yrjänheikki et al., 2011).

In industry, engineers have willingly adopted the notion of engineering ethics, but due to the myriad perspectives taken to the concept, its meaning remains somewhat elusive. The central tenet of the past that ethical duties can be fulfilled by simply operating in conformity with the law has expanded into more comprehensive insight into corporate social responsibility. Today, industrial ethical obligations extend beyond profit-making and legislative performance, including discretionary activities and compatibility with the social requirements posed by the surrounding community. Legal responsibilities include the minimum requirement of compliance with laws and regulations. Ethics practices reflect societal standards, expectations, and norms that have not been specifically legislated or governed. Moreover, philanthropic or discretionary responsibilities encompass activities that respond to societal expectations for good corporate citizenship (Smith et al., 2009).

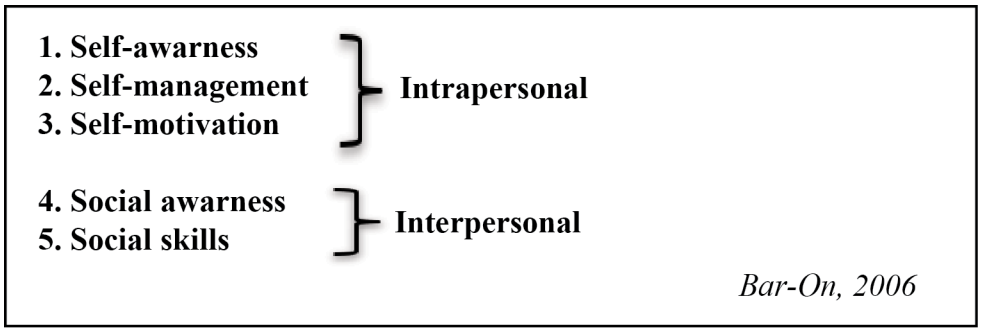
This all-embracing framework of ethics urges engineers to look for overall improvement of society and the quality of human life, on top of the self-evident technological advancement, commercial benefits, contribution to profits, and economic development. In all these activities, ethics is instrumental in enhancing reputation and image, leveraging employee commitment, retention and motivation, strengthening investor confidence, and securing competitive advantage through leveraged purchasing intents among consumers (Smith, 2009). Subsequently, ethical engineering is here referred to as a general approach to the responsible production of engineering products that materializes through socially concerned individual conduct and team processes at the workplace, thereby integrating both the macro-ethical dimensions obliging the engineering profession and the micro-ethical level of the individual.

EMOTIONAL INTELLIGENCE AS A CARRIER OF ETHICS

Discussion about micro-level ethics involves concepts such as human capital and individual capabilities, particularly socio-emotive skills. Research on emotional and social intelligence (or ability, potential, competence, or skill) has come a long way, from popularized and unempirical accounts to scientific models and frameworks depicting the fundamental elements and sources of socio-emotive competence. This section briefly reviews the key concepts and the most broadly researched approaches to emotional competence that to date have dominated empirical research: ability models, trait models, and mixed models (Bar-On, 2006). What all the models have in common is that they address the ability to perceive or identify emotions, employ emotion to assist cognitive processes, understand emotion for analytical aims, manage emotion to modify an emotional response in oneself and others, and to experience emotions (Brackett et al., 2006). They differ in what they conceive as the basis of the competence—thus far, it has not been solidly established whether emotional intelligence (EI), presently viewed as an essential working life quality, should be examined as a personality trait or learnable skill (Rose-Krasnor, 1997).

Ability models conceptualize emotional intelligence as a set of mental abilities pertinent to the cognitive processing of emotion-relevant information, viewing EI as a set of competences, hands-on skills, and qualities that can be learned and benefited from in effectively accomplishing working life tasks (Austin et al. 2005). The EI ability model views emotions as evolved signal systems where each emotion conveys a specific meaning. It defines EI as a capability to express and monitor one's own feelings and those of others, to discriminate among them and regulate one's emotions, and to use the information to guide one's behavior (Saarinen, 2007).

Figure 1. The main categories of social and emotional competences, modified from Bar-On (2006).



For proponents of the *trait models*, emotional intelligence is a trait viewed as a constellation of emotion-related self-perceptions and personality dispositions (Petrides et al., 2003). Instead of viewing EI as a constellation of competences or mental abilities or facilitators that can be developed, this model attributes differences in individuals' EI levels to the genetic origin (Petrides 2010). Traits are fixed or stable characteristics, which imply a lower degree of learnability or changeability (Kirkpatrick & Locke, 1991). Compared to the other two, the trait model acknowledges the inherently subjective nature of emotional experiences and subsequently its measurement as a self-perception concept (Petrides 2010).

Finally, *mixed models* address three categories of constructs: perceived abilities, competences, and personality traits. These models examine EI as a combination of cognition, meta-cognition, emotions, moods and personality, motivation, personal traits, and social habits that influence one's ability to cope with environmental demands and determine effective human behavior at the workplace but also in life, in general (Saarinen, 2007; Bar-On, 2005).

As described, all the approaches address both intrapersonal characteristics that involve self-leadership abilities, and interpersonal ones facilitating interaction with others. This chapter subsequently proposes an extension of the discussion from emotional intelligence to socio-emotive competence, in concord with Bar-On's findings (2006). His 15-factor model includes both traits and abilities and slices social and emotional skills into five main areas: 1) Self-awareness, 2) Self-management, 3) Self-motivation, 4) Social awareness, and 5) Social skills. The five meta-factors and the 15 sub-scales in the model address the following competences: 1) intrapersonal (self-regard, emotional self-awareness, assertiveness, independence, and self-actualization); 2) interpersonal (empathy, social responsibility, interpersonal relationship); 3) stress management (stress tolerance and impulse control); 4) adaptability (reality-testing, flexibility, problem-solving); 5) general mood (optimism and happiness). The framework, illustrated in Figure 1, correlates strongly with the Big Five model, the most widely established theory-describing personality (Bar-On, 2006).

How do socio-emotive competences relate to ethics, then? Discussion about ethics is discussion about responsibility themes. Individuals' level of ability in the areas presented in the above figure largely determines their contextual behavior in an engineering team: the extent to which they manage to take responsibility for their own conduct is in direct correlation with their capacity for self-regulation, and what they bring to the organization's culture and value system materializes through social interaction and communicative output. The next section deals in more detail with the impacts of individuals' socio-emotive skills on their work communities.

Impact of Socio-Emotive Capital on Organizations

Research in neuro-cognitive psychology has found empirical support for the existence of phenomena called emotional contagion or mood contagion. Such contagion derives from the capacity of mirror neurons to reproduce or mimic what other beings do. Accordingly, emotional or mood contagion refers to the human tendency to synchronize with the interlocutor's verbal and non-verbal or body language cues, resulting in emotional convergence and a sense of shared experience. Functional magnetic resonance imaging has revealed that this contagion occurs physically in the brain's limbic areas as a type of empathy (Goleman & Boyatzis, 2008; Dashborough et al., 2009). All normal individuals have the capacity to catch other people's emotions, but they vary in their tendencies to get swept up in them. Such variation results from genetics, personality traits, childhood environment, life history, and gender, contributing to people's susceptibility or resistance to emotional impacts (Wang et al., 2010).

Awareness of the impact of emotions should not be regarded as encouragement for theatrical exaggeration or fake display; rather, employees ought to keep in mind the responsibility related to communication—people rarely interact without transmitting any emotive meaning (Macagno & Walton, 2010). Open expressions that stimulate upbeat feelings and enthusiasm carry positive impact most effectively, which strengthens the business case for socio-emotive capital (Goleman et al., 2002).

An expanding body of research has established an association between emotions and organizational outcomes. Positive emotions attribute to the organization's cognitive performance and general well-being, reducing absenteeism, employee turnover, and demotivation (Chan & McAllister, 2014). Those capable of regulating their emotions by means of rational thinking are physiologically, cognitively, and socially healthier. Also in situations of change, the ability to direct attention to one's own emotions seems essential for success and professional development (Saarinen, 2007). Leader emotions are known to determine the quality of leader–subordinate exchange, mediating employee commitment and effectiveness (Sullivan, 1988). On national and societal levels, the emotive climate impacts citizen health, mortality, retirement age and the quality of life, with an ultimate effect on the public welfare and health care system (Hassard et al., 2014).

These findings highlight the paradox in engineering education. Despite societal trends, engineering syllabi continue to accentuate field-specific expertise, the bottom level described in Table 1, and largely ignore the potential sources of productivity offered by individuals' non-technical qualities, for instance personality, attitudes, and transferrable skills.

Let us next examine the connection between EI and ethics in industrial settings.

The Interplay between Communication and Ethics

Industries are alerted to the external, societal demands for corporate social responsibility and stakeholder pressure (Surroca & Zahra, 2012). But with growing awareness of the effects of employees' responsible conduct on the bottom line, this chapter discusses a shift of focus toward individuals' personal qualifications in the build-up of an ethics-conforming organization culture. Culture strongly determines what is regarded as ethical in an organization (Schein, 1987), and due to their hierarchical status, especially managers operate at the forefront in shaping the culture through the way they exercise power. Naturally, on all levels, employee motives determine their perception of ethics, that is, whether they are driven by a personalized motive or a socialized one. The former drives individual engineers to pursue their selfish agendas and go the extra mile to meet their self-centered needs, be they related to promotions,

Table 1. The make-up of a professional engineer. (Lappalainen, 2012)

Manifested level	***Communicati-on skills*** Assertion Inspiration	***Emotive skills*** Self-knowledge Self-motivation	***Cultural skills*** Empathy Openness
Personality level	***Motives*** Sociability Listening	***Values*** Responsibility Sustainability	***Attitudes*** Optimism Self-image
Domain expertise	***Substantive expertise*** Theoretical Practical Strategic		

rewards or power or other personal gains. Those driven by a socialized motive prioritize the common good and seek the benefit of the entire team, sometimes sacrificing their own personal dreams (Pöllänen, 2008).

With growing consensus on antisocial workplace behavior representing one form of unethical action (Shepherd et al., 2013), pressure for socialized motives urge employees to focus on the efficacy and impact of their communication style. Effective communicators aim at minimizing their interlocutors' emotional uncertainty by being as supportive as possible. An interactant who attempts to support the other participants by smoothing over any unpleasant situations focuses on verbally, vocally, and kinetically acknowledging and strengthening the other person's intrinsic worth as a person (Eelen, 2001).

In addition to benefits for social workplace interaction, effective communication induces advantages for the communicators themselves, as well. Certain communication strategies promote individuals' ethical image and deliberate performance in engineering communities effectively. Namely, latest findings from behavioral ethics indicate that few antecedents of unethical behavior correlate with unethical intention, and that instead of being rational and conscious, misconduct is often less intentional (Welsh & Ordonez, 2014). Studies in emotional intelligence lend support to these findings, indicating that human behavior is driven by emotions, the key psychological drivers that mobilize humans to action (Gooty et al., 2010; Charles et al., 2007) but sometimes also distort judgment and basic reasoning processes (Petrides, 2010).

In addition to automatic emotion-based thinking and intuitive behavior, ethical conduct is influenced by other factors. As a theoretical construct, virtue ethics emphasizes the role of character and person more than action (Culham & Bai, 2011). Further, self-image has recently been identified as an essential element of moral decision-making. As individuals balance multiple objectives when making moral judgments, their primary focus is directed to maintaining their self-concept and worth (Welsh & Ordonez, 2014). Therefore, if individuals, on the one hand, are not always even aware of their misbehavior, and on the other, if components of self and identity determine their ethical decisions, perhaps self-awareness, the foundation of EI (as shown in Figure 1), deserves more attention in ethics studies and engineering curriculum design.

Self-awareness as the cornerstone of self-management is subsequently introduced here as the first building block of ethics communication. As shown in Figure 1, self-regulation is founded on self-awareness and proves crucial in individuals' attempts to regulate their behavior in conformity with their own moral standards and those of the surroundings. This way their personal value system, closely linked to self-awareness, contributes to ethical agency (Shepherd et al., 2013).

Assertion is of prime value in engineering ethics discussions revolving around moral choices. It refers to people's tendency to constructively and proactively speak up for or reactively defend their

own values, interests, or goals (Ames & Flynn, 2007). Assertion is particularly crucial for social issue supporters, who are sometimes forced to take career or image risks when defending their values and beliefs. This is often the case in situations where the organization's contextual cues are unsupportive of the individual's social causes (Sonenshein et al., 2014).

Another important communicative dimension of ethical conduct is *empathy*, known to correlate negatively with moral disengagement. Empathy means perspective taking or the ability to construe other people's points of view, both cognitively and emotively (Shepherd et al., 2013; Johnson et al., 1983). Besides being instrumental for moral identity, empathy enables genuine and meaningful interaction among members of engineering teams, facilitating also dialogue about controversial ethics issues.

To conclude, such aspects of emotional intelligence as self-awareness, assertion, and empathy are not just soft communication strategies mediating the quality of employee relationships. More importantly, they determine the organizational culture and value base, reveal the quality of individual engineers' morale stance, color discussions about polemic ethics issues, and provide instruments for conflict management.

ENGINEERING SYLLABI AS VENUES OF ADOPTING ETHICAL THINKING

The intensifying calls for humanitarian engineering and globally responsible industrial activities have shaken the foundation of traditional engineering education and suggest a shift away from the merely technical syllabi. Instead of serving as hearths of substance matter disseminating traditional scientific knowledge to graduates, universities should offer adaptive education that harnesses students with working life skills (Lappalainen, 2012).

Unfortunately, technical rationality with its long tradition still dominates our views, justifying criticism of the current education system for not producing and disseminating the practical competency relevant in today's society. Engineering institutions are increasingly accused of an excessive focus on epistemological academic activities that do not necessarily help secure professional artistry (Schön, 2005). Subsequently, the advancement of the current higher engineering curriculum should aim at transforming the narrow focus and depth of knowledge in a single area into an extended avenue toward full-scale professional expertise (Newswander & Borrego, 2009).

For intra-organizational motivations, such as workplace climate, employee commitment, and industrial effectiveness and productivity, and for such societal and global reasons as climate change, gender equality, and sustainability, ethics is presently regarded as a component of professional expertise. As organizational socialization is unlikely to alter the fundamental value structure an individual brings to the organization (Judge & Bretz, 1992), employees' value bases should be influenced already prior to their entrance to working life. Unfortunately, engineering education in Europe has a firm tradition in technical contents and in being strongly driven by subject matter. This creates pressure to respond to the paradigm shift transitioning the educational focus from measurable, content-related learning outcomes to the learning process, moving education from didactic to more student-centered approaches such as cooperative and experiential learning (Brodie & Porter, 2008; Fernandez et al., 2009). This also serves the aim of reducing traditional emphasis on the mere transmission of knowledge while encouraging students to understand, investigate, and solve problems that are morality, values, and ethics (Sanchez et al., 2008).

Classroom Experiment with Ethics

Thanks to the myriad studies that have established the correlation between socio-emotive competences and success in working life or life in general, the notion of emotional or social intelligence has been well received also in the educational context (Culham & Heeson, 2010). Research abounds in descriptions of experiments from pedagogies pursuing holistic professional build-up through university education. Such methodologies include problem-based learning (Borges et al., 2009), student empowerment (Frymier et al., 1996), cooperative learning (Garside1996), and teacher immediacy (King & Witt, 2009). As individual theories I would like to single out the Intentional Change theory by Boyatzis and Akrivou (2006), which takes a deeper approach to the development of personal qualifications and character than many pedagogic methods addressing student abilities. Also virtue ethics as a classroom philosophy could serve as a framework encouraging students to pursue their telos, or fundamental purpose in life and thereby their better selves. Succinctly put, ethics and socio-emotive competences can readily be taught together as they both depart from the same platform, that is, one that sees individual's development as a result of his or her own, conscious effort in the context of trusted others (Culham & Heeson, 2010).

This chapter enumerates an experience from integrated teaching that brought together industrial topics such as strategy, leadership, finance, emotional intelligence, and ethics in an English language course. Research indicates that teaching within the context of a subject area and using cases drawing from real-world phenomena is the most effective way of promoting long-term learning outcomes and enhancing critical thinking, insight, knowledge and creativity through experience-based learning. In addition, analyses of such authentic cases that mirror reality encourage students to apply theoretical knowledge to practice (Garside, 1996; Kreps & Lederman, 1985). The course therefore only employed material and examples from real life, resorting largely to the lecturer's work history in telecommunications and recent media cases.

As an exercise supporting the build-up of personal qualifications in the field of ethics and values, the lecturer experimented with a two-part Personal Values assignment, with one written and one oral component. The theme was introduced with theory and definition of values, ethics, and morale, research findings demonstrating the value of ethics for industry, and a few case studies describing severe misconduct in an engineering corporation. As their first, written task, students were asked to write an essay where they described two or three of their personal or professional values that served as guidelines in their daily lives. It was essential to provide evidence backing up the authenticity of the selected values by articulating how these values materialized in their lives and by revealing situations where they had made it a point not to compromise them. Second, they challenged each other to defend their values in a job interview simulation, with a jury of three peers asking questions and urging the interviewee to describe his or her moral identity.

Despite the level of difficulty for young adults with no previous experience in values thinking, and with the interviews conducted on a foreign language, the students merited this exercise among those in their language studies with the highest value and relevance to their future careers. They credited the benefits to being forced to identify what truly mattered to them, which deepened their self-knowledge, and to articulating, justifying, and defending their values out loud in a group, which gave self-assurance in terms of future job seeking and interviews.

As one student wrote in course feedback, "Thinking about your own ethics and company ethics prepares us well for job interviews and it was good to practice them too."

FUTURE RESEARCH DIRECTIONS

This chapter substantiated the shift of attention in engineering industries to such socio-emotive abilities as self-awareness, assertion, and empathy, giving credit to their role and potential as carriers of engineering ethics in micro-level interaction. No doubt, also other EI components yield gains for the organizational value base, but their role and impacts require closer examination. Further, in terms of ethics pedagogy, this writing only scraped the surface and therefore more methodological analysis of classroom activities and assignments promoting awareness of ethics and follow-up of learning outcomes are in order. In particular, the role of teachers in the contagion of emotions and moods and as examples of the application of EI and ethical conduct deserves more attention. The fact that humans mimic and model after others places huge expectations on pedagogues, yet also offers potential. If not for the purposes of social and emotional learning, this is crucial as emotions are known to be involved in cognitive learning and retention of learning outcomes (King & Witt, 2009; Culham & Bai, 2011).

Finally, many universities still lag behind in university–industry collaboration, with no common ground smoothing the educational shift from content memorization to adoption of contextual qualifications. This chapter serves as a plea to all those operating at the university–industry interface—more intensive collaboration for instance through treatment of authentic industrial cases would aid both ends.

CONCLUSION

Our society can no longer afford to ignore responsibility themes, not merely because of the challenges induced by pollution and climate change but also for reasons of individuals' mental fulfillment and the negative impacts induced by value voids.

To allow engineering industries to pursue ethical operations and outcomes in the most effective way possible, they need individual engineers that are ethical and prepared for this compelling ideological leap from a focus on financial corporate profits to more extensive societal gains. It is too late to leave the build-up of their moral identities to organizational socialization; instead, universities should come to rescue and incorporate ethics and values themes more systematically into engineering curricula. The discursive and intellectual approaches that currently prevail in engineering education risk ignoring the moral education required of global citizens. Adding ethical considerations will support the build-up of the virtuous person, or the virtuous engineer, that unwaveringly makes moral decisions not on the basis of external incentives but in concert with his or her personal value system.

To conclude, professionalism in tomorrow's engineering teams is founded on individual engineers' value systems that allow the employees to communicate with others with self-awareness, assertion, and empathy. With tedious and methodological syllabus design, our industries will eventually be manned with engineers whose moral identities are not compromised in pursuit of their selfish agendas but who rather view the world around them with care, concern, appreciation, and a sense of social responsibility.

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KEY TERMS AND DEFINITIONS

Assertion: People's tendency to constructively and proactively speak up for or reactively defend their own values, interests or goals verbally and nonverbally.

Communication: The process by which information is transferred and understood, with the ultimate aim of building communality and establishing a foundation for human interaction.

Competence: Possession of a practical skill, theoretical or intuitive knowledge, qualification, or capacity.

Emotional Intelligence (EI): Ability to perceive, access, recognize and generate emotions so as to assist thought.

Empathy: Ability to understand and be sensitive to the feelings, thoughts, and situation of others.

Interpersonal Skills: Intelligence providing the capability to perceive, understand and react to other people's moods and motives.

Intrapersonal Skills: Intelligence offering the capability to form an accurate model of oneself and to use this model effectively.

Socio-Emotive Competence: A set of emotional, personal and social knowledge and abilities that promote coping with environmental demands and pressures.

Chapter 15
Conflict Resolution and Ethical Decision-Making for Engineering Professionals in Global Organizations

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ABSTRACT

As an introduction to recognizing individual and organizational conflict as well as ethical issues within global firms, the goals of this chapter are to equip Science, Technology, Engineering, and Mathematics (STEM) professionals, especially those in engineering, with solid decision-making tools, including self-awareness, ethical perspectives and theories, ethical decision-making models, and various conflict resolution approaches. Given the current challenges in business and industry that have often led to unethical practices, and ultimately conflict, it is critical that both organizational leaders and followers possess the necessary tools and perspectives to create an ethical climate that deals appropriately with various types of conflict. This chapter examines new trends in conflict coaching and the delivery of ethics training in an effort to provide the aforementioned tools and perspectives.

INTRODUCTION

Conflict and decision-making impacts all humans at some point. One need only tune in to the local or national newscast, pick up a magazine or go to the local library to learn that conflict is very much a part of the human condition. Nations are at war, people sometimes do horrible things to each other, relationships and marriages are often a challenge, belief systems and ideologies cause

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intrapersonal and interpersonal conflict, and the workplace is regularly described by leaders and followers as stressful. This is especially true in the intense, internationally diverse, high-energy, pressure-packed, STEM fields. In short, conflict resolution and ethical decision-making is something that every engineering professional must understand and embrace to be successful in global organizations today.

Answers to the issues surrounding ethical decision-making should be researched, formulated, implemented and become part of the organizational culture, climate and daily discourse if the workforce is to thrive. Ethical decision-making skills are not just "common sense"; they are complicated sequences of relational skills that most humans don't know or understand (Wilmot & Hocker, 2007). There have been numerous books written about and significant research performed on the topics of conflict management and ethical decision-making (Ayers, 2008; Crenshaw, 2007; Furlong, 2005; & Gerzon, 2006).

Many organizations hold ethical decision-making seminars, conflict resolution/ management training seminars, and mediation seminars. They also design and develop performance/motivational tools and climate/culture audits to better understand the true nature of the workplace. Most organizations have developed employee handbooks that define expected compliance with both organizational rules and regulations, and often integrate ethics as a key piece of the handbook. Additionally, many university based graduate programs that cater to working engineering professionals have developed ethics and conflict resolution courses as part of the curriculum. Each of these efforts has one thing in common; there is often a third party who takes responsibility for expected outcomes.

What requires a more detailed examination are the efforts to build capacity among employees to address their own ethical decision-making skills and conflict situations rather than relying on a third party or external decision maker to solve problems after they have arisen. Although third-party approaches can be beneficial, there is often no better method for achieving a truly effective, lasting resolution to an ethical or interpersonal conflict than placing the responsibility of managing it in the hands of those who experience it directly. Unfortunately, many employees do not possess the skills and confidence to manage conflict and ethical decision-making resulting in organizations relying not on the individuals within the situation, but on true third-party approaches, that are facilitated by managers and/or the human resources department. The need for new and innovative approaches to address organizational conflict and ethical decision-making is significant, and this chapter will provide new insights in creating a more meaningful ethical decision-making model as well as conflict coaching environments within organizations.

Whitbeck (1998) believes that engineers encounter difficult ethical problems from day one on the job and likens these issues to "design problems." He and other engineering ethics researchers (Harris, Prithcard, Rabins, James, & Englehardt, 2014; van de Poel & Royakkers, 2011 and Whitbeck, 1998), have found that ethical challenges are complex and often ill-defined, and that resolving them involves an iterative process of analysis and synthesis. These researchers also believe that professional engineers struggle with professional responsibilities, personal values and a responsibility for human welfare. Multiple solutions to these "design problems" can confound the engineering professional and conflict with deeply held personal and professional beliefs. According to a National Science Foundation Report (2014), barring large reductions in retirement rates, the total number of retirements among science and engineering-degreed workers will dramatically increase in the next 20 years; particularly those workers holding PhDs because of the steepness of their age profile. During that time, as many new engineers enter the profession, it is clear that soft skills such as conflict resolution and

ethical decision-making will continue to gain in importance.

According to researchers (Fleischman, 2012; Carnevale, Smith, & Melton, 2011) US employers are struggling to address the national challenge of finding qualified workers in science, technology, engineering, and mathematics (STEM) fields. STEM fields are critical to U.S. economic competitiveness and growth and represent the foundation of the knowledge-based global economy that will provide high-skilled jobs. American business leaders warn that the supply of qualified STEM workers is not keeping pace, and many believe that the US reputation as the world's premier science and technology innovator is declining. Ensuring the nation has a sustainable STEM pipeline of high-quality STEM workers is a priority for all STEM stakeholders, including university preparation programs.

President Obama highlighted STEM education and its importance to jobs and the economy in his 2013 State of the Union address (Obama, 2013). This issue affects a surprisingly wide array of industries, from technology to energy, manufacturing, healthcare, retail, and others. STEM education and workforce gaps have implications for individual companies and the American workforce. A highly skilled and trained STEM workforce plays a vital role in US economic prosperity, innovation, and security. An estimated $1.2 trillion is spent annually in the United States to develop, attract, and retain a capable STEM workforce (Carnevale, Smith, & Melton, 2011); by many accounts, however, that spending is not achieving the desired results. America's advantage over its international competitors in STEM is waning.

A major reason for this trend is US students' declining interest and proficiency in STEM fields, especially engineering. According to the National Center for Education Statistics, the United States in 2009 ranked 25th in children's math achievement among 34 countries studied (Institute of Education Sciences, 2010). Deficiencies in the US education system are a major reason for the STEM talent crisis, but there are others, such as the role that industry plays. US companies invest significantly in STEM initiatives, often to seed the engineering talent pipeline. Yet employers still encounter difficulty in filling STEM jobs in engineering and technology. In a 2012 survey conducted by American Public Media's *Marketplace Education* and *The Chronicle of Higher Education,* businesses in the science and technology industries reported struggling more than many other industry segments to fill open positions, rating their difficulty a 3.75 out of 5 (the highest difficulty) (Chronicle of Higher Education, 2012).

Certainly the lack of a cohesive effort to attract, train, and retain STEM leaders and workers is currently on the radar of many STEM stakeholders. However, certain aspects of the problem must be recognized before those who prepare STEM employees can fully realize all of the serious issues facing STEM worker preparation. So much is made of content area skills in science, technology, math, and engineering, that often "soft skills" such as written and verbal communication, tolerance of diversity, ethical decision-making skills and conflict resolution skills are not emphasized.

BACKGROUND

The need for new and innovative approaches to address ethical decision-making and organizational conflict in STEM organizations is substantial. This chapter provides new insights concerning how organizations are better prepared and employees can adequately address their ethical conflicts independently without third-party intervention. The organization needs to provide the skills, tools, and strategies for doing this, and consider the most productive, efficient, and effective ways to deliver training for busy professionals.

This chapter is written for any STEM professional needing support from his or her organization regarding how to handle conflicts independently without asking for the organization to intervene.

Additionally, decision-makers in STEM organizations will benefit from reading and understanding the concepts found in this chapter. Finally, STEM leaders will have a better understanding of the issues that lead to conflict and ethical decision-making on the part of those involved. Engineering faculty, organizational leaders, managers, and supervisors, STEM employee peers, co-workers, team leaders, or other individuals in a relationship with an employee for whom they'd like to offer support in ethical decision-making and/or managing a conflict situation will gain from reading this chapter.

ENGINEERING ETHICS DEFINED

According to Martin and Schinzinger (2010) the terms ethics and engineering ethics have several meanings. They believe that in one sense, ethics is synonymous with morality and refers to moral values that are sound or reasonable, actions or policies that are morally required (right), morally permissible (all right), or otherwise morally desirable (good). Accordingly, engineering ethics consists of the responsibilities and rights that ought to be endorsed by those engaged in engineering, and also of desirable ideals and personal commitments in engineering (Martin and Schinzinger, 2010). Ethics is also the activity (and field) of studying morality; it is an inquiry into ethics in the first sense. It studies which actions, goals, principles, policies, and laws are morally justified. Using this concept of ethics, engineering ethics is the study of the decisions, policies, and values that are morally desirable in engineering practice and research (Martin & Schinzinger, 2010).

Other researchers believe the study of engineering ethics focuses on engineers as professionals (Harris, Pritchard, Rabins, James, & Englehardt, 2014; Culver, Puri, Wokutch, & Lohani, 2013; Fleddermann, 2004) asserting that engineering ethics should be distinguished from personal and social ethics outside the context of engineering practice. The codes of ethics of professional engineering societies provide a useful framework for addressing many of the ethical issues that arise in engineering according to Harris, et al. (2014). However, these codes can be expected to change through time, and earlier codes emphasized engineers' primary duties to their employers and clients. However, by the 1970s, most codes insisted that the first duty of engineers was to protect public safety, health, and welfare. More recently, many codes have begun emphasizing the importance of sustainable technology and protecting the environment (Harris, et al., 2014).

As a profession, engineering can be expected to commit to morally desirable goals, pursued in morally acceptable ways (Harris, et al., 2014). The public, employers, and clients depend on the responsible use of engineering expertise. Although the study of engineering ethics can be expected to concentrate much of its attention on wrongdoing and its prevention, it also should be concerned with the positive promotion of good (Harris, et al., 2014).

ETHICAL DECISION-MAKING AND CONFLICT

It is quite easy to make the economic, business, and leadership imperative for the delivery and use of a high-quality ethical decision-making and conflict resolution techniques that organizations can use to improve. There are significant tangible and intangible costs related to poor ethical decision-making and unresolved organizational conflict, such as:

- Lost revenue
- Employee turnover and retention costs
- Impacts on morale, employee engagement, etc.
- Health costs
- Loss of reputation and goodwill.

Additional costs result from employer-provided health care insurance covering the cost of injuries and illnesses, crisis intervention, and group and individual counseling for victims of conflict, witnesses, and their families. Clearly, it is in the best interest of both the business and the individual to ethically resolve conflict before it escalates.

Numerous reports and publications track the instances of conflict that lead to workplace violence and the economic impact on organizations and the economy. The Society for Human Resource Management Workplace Violence Survey, published in 2012, found that over one-third (36 percent) of US organizations reported incidents of workplace violence. According to the Occupational Safety and Health Administration (2012), about 2 million US workers per year report having been victims of some kind of workplace violence. The US Department of Labor's Bureau of Labor Statistics (BLS) surveys workplace injuries, illness, and fatalities including those caused by workplace conflict and violence. In 2012, the BLS found there were nearly 3 million nonfatal workplace injuries and illnesses reported by private industry employers, resulting in an incidence of 3.4 cases per 100 equivalent full-time workers. Another tracking source is the Liberty Mutual Research Institute for Safety Workplace Safety Index, which tracks the incidence and workers' compensation costs of "the most disabling workplace injuries and illnesses" (defined as those causing an employee to lose 6 or more workdays). The 2012 annual index found assaults and violent acts as the 10th leading cause of nonfatal occupational injury during 2009, at a cost of $590 million. Experts agree that billions of dollars are lost each year in time, productivity, litigation, and added security measures as a direct result of conflict that can lead to workplace violence.

Recently, there have been some remarkable examples of ethical malfeasance on the part of business, industry, profit, nonprofit, and government organizations. In the last 20 years, names like Enron, Arthur Anderson, Tyco, Martha Stewart, Bernie Madoff, Merrill Lynch, Bear Stearns, General Motors, Chrysler, Fannie Mae, and Freddie Mac have instilled a certain fear in those who believe in capitalism and a democratic society. Ethical breaches on the part of all those mentioned above and thousands more small business owners have adverse effects not only on the economic well-being, but also on investor confidence. Unethical behavior also contributes to a perception that business is not a place that the best and brightest should choose as a profession. Depending on the size of the organization, an incident of ethical malfeasance and/or workplace violence will draw the attention of directors and shareholders causing concern in the community, especially if there are massive layoffs, injury, or loss of life involved. The organization may suffer a loss of public trust, damage to both reputation and public image, dilution of value, and loss of business relationships, the result of which draws the attention of the media that may necessitate a coordinated public response.

Finally, in addition to managing the impact on reputation, employee morale, lost revenue and shareholder confidence, ethical lapses, and incidents of workplace conflict may subject the organization to the intervention of external constituents. Criminal actions may involve multiple levels of law enforcement with jurisdiction to interview witnesses and make arrests. Government agencies and state counterparts may have authority to conduct investigations, interview victims and witnesses, and issue citations, assess penalties, and, in extreme cases, impose criminal sanctions.

Clearly, there is a need in all organizations, especially in STEM organizations, to provide employees with a skill set to make ethical decisions and resolve conflict before it escalates. Efforts should be made to build capability among STEM employees to address ethical and conflict situations directly instead of relying on internal or external decision-makers to do so. Universities that confer STEM degrees are in a unique position to partner with the constituents they serve by preparing

graduates that have a solid ethical foundation and the ability to solve conflict on their own.

Arguably, US engineering education programs emphasize STEM content over what some would call "soft skills" such as ethical decision-making strategies and conflict resolution, making it difficult for degree programs to fit all of the necessary courses and seminars into the curriculum. Additionally, many states have reduced the number of credit hours they will allow universities to offer within degree programs. This perfect storm has left soft skills acquisition in STEM degrees as less than a priority for STEM educators. This trend must be reversed if universities are to contribute to the creation of a steady pipeline of the right kind of STEM workers and leaders in the future.

SOLUTIONS AND RECOMMENDATIONS

Introduction

STEM educators should play a key role in ensuring that all STEM undergraduate and/or graduate students have knowledge, skills, and abilities (KSA's) in ethical decision-making and conflict resolution. Additionally, universities should become involved in providing high-quality professional development for practicing STEM professionals. The key to providing KSAs is to develop a curriculum based on the needs of the STEM profession, create a user-friendly, reusable, accessible delivery system, and market the opportunities effectively so that STEM students and professionals are aware and interested.

There is a vast need for an empowerment model for ethical decision-making and conflict resolution, so that organizations enable individuals to create and embrace their own ethical decisions and resolve conflicts rather than to be continually dependent on an external source to step in. The trend is to move away from a patriarchal, dependency model of management, where employees are controlled and manipulated, to a partnership model where employees are supported and empowered to direct their own actions (Avruch, 1998; Doherty & Guyler, 2008; Griffith, 2012; Goodwin & Griffith, 2013; Jones & Brinkert, 2008).

The keys to this model include:

1. STEM students and professionals understanding themselves and self-managing.
    a. issues that they will face in a high-powered, fast-paced, high-pressure STEM
    b. environment
2. A general understanding of ethical perspectives necessary to make ethical.
    a. decisions and resolve conflict is developed and delivered
3. Students and professionals exposed to and understanding ethical decision- making and conflict resolution techniques.
4. STEM employees and leaders developing an ethical and conflict-free organizational.
    a. climate
5. Managing conflict by using a variety of coaching techniques.
6. Leading and managing ethical and conflict crises when they occur.

Self-Awareness and Understanding

Self-awareness is recognizing your motivations, preferences, and personality and understanding how these factors influence your judgment, decisions, and interaction with other people (Cooper, 1998). Humans that are self-aware have a clear idea of how they are feeling and why. More importantly, self-awareness involves the individual capacity to monitor and control bias that all of us can hold and that often impacts our ability to make good decisions. Internal feelings and thoughts, individual strengths and limitations, personal interests, values, goals, leadership orien-

tation, and preferred learning and communication styles are some of the vast array of elements that comprise self-awareness (de Janasz, et al., 2012). Self-awareness is often considered the foundation for being an effective employee and can help us 1) understand ourselves in relation to others, 2) develop and implement a sound self-improvement program, 3) set meaningful life and career goals, 4) develop high-quality, lasting, meaningful relationships with others, 5) embrace diversity, 6) lead ourselves and others effectively, 7) increase productivity at work, and 8) develop an ability to contribute to organizations, the community, and family (de Janasz, et al., 2012).

Self-awareness can begin with the conscious choice to begin the process of recognizing individual weaknesses, strengths, biases, attitudes, values, and perceptions. Of course there are many ways to begin this process of recognition, but usually self-analysis is a starting point. Often, the self-analysis process begins with guided self-reflection and through the use of numerous tools including reflective journals (Loo & Thorpe, 2002). Additional tools for self-analysis consist of psychometric instruments including the Myers and Briggs Type Indicator (Myers & Briggs, 1980), the Gregorc Style Delineator (Reio & Wiswell, 2006), The Emotional Intelligence instrument (Goleman, 2004), and The Big Five Locator (Barrick & Mount, 1991). These instruments are helpful to determine key concepts including behavior, personality, attitudes, and perception.

Behavior consists of motivation, modes of thinking, modes of acting, and modes of interacting. All behavioral elements are extremely important when making ethical decisions and addressing and dealing directly with conflict, and it is imperative that those making decisions understand what inherently motivates them, how they think about others and the world around them, why they act the way they do, and what different modes of action are available to them.

Personality consists of traits such as extroversion, agreeableness, emotional stability, conscientiousness, and openness to experience. In addition are the personality traits –consisting of the ability to self-monitor, which is the tendency to adjust behavior relative to the changing demands of social situations. The concept of monitoring your own personality can assist with personal understanding of the positive qualities that we all possess, and those qualities we might like to change.

Attitudes are narrow, can vary from situation to situation, and are learned dispositions to respond to an object in a favorable or unfavorable way (Poctzer, 1987). The emotions we choose to act on can influence and ultimately determine attitude. Attitude then is reflected by specific behavior. It is important to understand our emotions, how they influence attitude, and how that influences and informs ethical decision-making and conflict resolution.

Perception describes the process by which individuals gather sensory information and assign meaning to it. Of course perception is not always consistent with reality because it is the perceiver's interpretation of reality. Perceptions are often formed based on human biases and are influenced by many factors including culture, environment, heredity, the media, peers, past experiences, intelligence, emotions, attitudes, and values (de Janasz et. al., 2012). Whereas it is important for STEM professionals to be aware of their perceptions, it is also very important to be aware of what others in the organization perceive and how they form perceptions.

Finally, self-disclosure and diverse experiences are two additional ways to gain self-awareness. In a STEM environment, stakeholders are not often encouraged to share thoughts, feelings, and ideas with others as a result of many factors that contribute to the climate and culture in the workforce. Often there are sensitive clearance issues and STEM organizations are very secretive about technical discoveries they are working on. This often results in a "culture of silence" where employees do not communicate with others openly, honestly, and without self-deception or distortion.

Sharing with others, especially diverse others, allows us to share our feelings and responses, and this type of disclosure in the workplace is an important factor in improving self-awareness. Diverse experiences help STEM employees develop skills and an experience base that helps test values, perceptions, and attitudes.

Ethical Decision-Making and Behavior

Ethical behavior can be black and white, where laws, corporate regulation, or shared moral values can guide and govern our actions. However, it can also be open to individual interpretation. Ethical behavior for one person may not always be the same given similar situations and may not always be consistent with the ethical behavior of others. Rest (1986) defines ethical behavior as a psychological process through which one course of action in particular is morally right whereas another is morally wrong. Hunt & Vitell (1986) say that ethical behavior is done by selecting the most ethical alternative out of the available options (p. 763). Although these are very similar they differ in that Hunt & Vitell (1986) suggest that one must have compared behavioral options and selected the best whereas Rest does not require it. However, both do not reference the possibility that an individual or group may not be aware of all their choices and their ethical behavior is limited through bounded rationality. Bounded rationality posits that individuals make decisions under constraints of cognitive and information-processing capability, incomplete information, and the influence of cultural beliefs (McGinnis, 2011).

We must not only be cognizant of ethical behavior, but we must then begin to identify when we are faced with ethical dilemmas that require making ethical decisions in either our professional or personal lives. But what are these dilemmas and how do they lead to ethical choices and ethical decision-making? According to Ghillyer (2012), an ethical dilemma is a circumstance that requires us to choose between opposing values that are significant to either the individual or the organization. Ethical dilemmas can range from impacting a single individual, including yourself, to impacting a large group of people such as a company, consumers, or an entire community. Examples of ethical dilemmas that can lead to ethical choices and decision-making in the STEM disciplines range from being offered an extra gift from a vendor to securing a contract, to an organization's decision to ignore possible pollution, to a community from their manufacturing facilities to achieve greater profit.

One large issue in identifying ethical dilemmas, especially when it involves part of a team in the workplace, may be the fact that not all of our colleagues may see the situation in the same way we see it. Different people may have different ethical perspectives as we have discussed earlier in the chapter. But there also may be what Hartman & Desjardins (2011) term as "perceptual differences" which is how individuals view the ethical situations or issues based on their own experience. So the first step in addressing an ethical dilemma may be the pure acknowledgment of it as well as the understanding of all the facts (Desjardin, 2011; Ghillyer, 2012; Hartman & Desjardins, 2011; Johnson, 2012a).

But how do we then resolve an ethical dilemma? Or make a decision involving an ethical issue or problem we are faced with either in the workplace or in our personal lives? The best approach might be the use of an ethical decision-making model. Empowering employees to use these types of methods is not only an important structural or governance issue, but also assists employees in making better ethical decisions (Johnson, 2007).

There are many models we may try depending on the ethical issue at hand. One simple model involves only three steps and would be best applied to those ethical problems that are more straightforward. As Ghillyer (2012) explains

Step 1: Involves *analyzing the consequences of the situation*, and determining both who will be helped by what you do and then who will be harmed;
Step 2: Then requires us to *analyze the actions* or consider all the options from a different perspective taking into account various principles and values that may apply;
Step 3: We *make a decision* after careful thought on the analysis we have just performed on which option offers actions that are least problematic (pp. 9–10).

For situations that may require a little more analysis, Desjardins (2011) offers the following method:

1. Understanding the facts.
2. Identifying the ethical issues involved.
3. Identifying all stakeholders.
4. Understanding how those stakeholders will be affected.
5. Employing moral imagination to understand alternatives.
6. Considering how others will judge your decision.
7. Making a decision and monitoring and learning from the results (p. 17).

This model is particularly effective for more complex ethical dilemmas as it considers all facts, identifies all stakeholders and all relevant principles, and then reinforces follow-up with the decision afterward.

Kidder's nine-point model (Johnson, 2012a) is a final solution for the most complicated of ethical issues we may face, especially in the workplace today:

1. Recognize that there is a problem.
2. Determine the action.
3. Gather the relevant facts.
4. Test for right-versus-wrong issues.
5. Test for right-versus-right values.
6. Apply the ethical standards and perspectives.
7. Look for a third way (an alternative to competing factions).
8. Make the decision.
9. Revisit and reflect on the decision (pp. 248–249).

Where Kidder's model differs from Desjardin's is in a more thorough examination of both the issues and values involved in comparison to the stakeholders.

Which model is right for you? That will depend on the ethical issue you are debating and what you should consider in making your final decision. It also may be helpful to employ several ethical perspectives and/or models in order to cover a wide variety of viewpoints so that you reach the best possible decision.

Organizational Climate: Ethical and Conflict Minimal

As we now can understand what it means to have ethical behavior; recognize and acknowledge ethical dilemmas; and apply an ethical perspective to our ethical problem, we are ready to turn our attention to the STEM environment and how we can ensure our organization has an ethical climate.

In order for any organization to have an ethical climate, leadership must be both concerned and supportive about this aspect of the organization (Johnson, 2007; Trevino & Nelson, 2007; Stanwick & Stanwick, 2014). This is often what we refer to as *corporate governance* or how organizations are led (Ghillyer, 2012). The goal of an organization's structure of corporate governance is to make sure that the needs of all stakeholders are met (Stanwick & Stanwick, 2014). Besides, managers and management team that may be in place with such officers as CEO – Chief Executive Officer, COO – Chief Operations Officer, CIO – Chief Information Officer, and CFO – Chief Financial Officer, may help lead organizations today. Of course, it matters if a company is private or pub-

lic to a certain degree, as it may then have both shareholders and an elected board of directors to help run the company – but all organizations will have stakeholders to consider (Ghillyer, 2012; Stanwick & Stanwick, 2014).

No matter the exact structure of the company, effective corporate governance toward an ethical climate can be achieved by putting into place certain elements or traits. These include such aspects as *trust, openness, communication, accountability*, and *leadership's interaction with the board* as well as *evaluation of board members* (Ghillyer, 2012; Trevino & Nelson, 2007). It is important to realize that corporate governance is about more than processing a list of items within an organization or putting a few audits in place to keep things in check (Ghillyer, 2012, p. 96). It is crucial to include ethics in an organization's values or mission statements, have ethics present within the company's policy manual and in new employee training (Trevino & Nelson, 2007). New trends in shaping an organization's ethical climate also include the use of both ethics training programs and corporate ethics officers for compliance. We will discuss ethics training programs below in the section entitled "Future Directions."

As Johnson (2012a) notes, there is no single method for producing an ethical climate within an organization. Instead we must recognize the principles and procedures that are identified within healthy ethical climates and then modify our organization's environment to include such elements. Those critical elements include: "zero tolerance for destructive behaviors, integrity, justice, a focus on process and structural reinforcement." Some indicators of an organization's ethical failure include "pressure to maintain numbers, fear and silence, bigger-than-life CEO's, a weak board" and "conflicts of interests" (pp. 323–324). But it is important to note that no matter what an organization may do to send the message of an ethical climate within their organization and prevent ethical collapse; the greatest step would be some sort of assessment that would be in place to evaluate the firm's corporate governance and compliance system (Stanwick & Stanwick, 2014).

Ethical crisis leadership is about making ethical decisions when one's company or those around the company are in crisis. Many individuals have written about the stages of a crisis situation. For example, Darling (1994), while focusing on effective crisis management, focused on four areas of a crisis:

1. **Prodromal Crisis Stage:** This is the warning stage that a crisis is coming. This stage does not always happen.
2. **Acute Crisis Stage:** This is the point where management must be acting to deal with the crisis or they may never make up ground.
3. **Chronic Crisis Stage:** This is the stage where audits, expositions, government investigations, interviews, and explanations will take place.
4. **Crisis Resolution Stage:** This should be the stage where all other stages lead to, where the issues around the crisis are resolved.

Seeger, Sellnow, and Ulmer (2003), in their book on communication and crisis posit that there are three stages of a crisis.

1. **Pre-crisis:** Is the stage between crisis events. Organizations may become complacent or over-confident during this time. This occurs especially as the time between crises events increases. This is often where warning signs appear and may be ignored.
2. **Crisis event:** Is where the crisis occurs. This is also a point were confusion can play a prominent role while facts are in shortage.
3. **Post-crisis:** Is where investigations take place. Finger pointing also often occurs as individuals and groups try to place blame until the crisis is resolved (Johnson, 2012b).

Jordan-Meier (2011) points to four stages of a crisis as it relates to the impact of media cover-

age of a crisis. They are fact-finding, unfolding drama, finger-pointing, and fallout/resolution. She also points out that media has shifted from large press organizations being the sole source of information to news coming from individuals on the ground who are near to, involved in, or impacted by the crisis event. Because of these changes in information gathering and sharing/reporting even what used to be the most minor incident can now easily become a crisis.

No matter how a crisis is broken down, the role of an ethical leader is paramount at each stage. Before a crisis occurs an ethical leader should help their organization detect potential issues and help them develop strategies for dealing with a crisis event should it occur (Darling, 1994; Johnson, 2012b). The 2011 Sony Entertainment Play Station hacking scandal is a prime example where ethical leadership in planning could have resulted in a much better outcome. Sony shut down their Play Station Network for seven days before they revealed that over 77 million users' data had been stolen (Stuart & Arthur, 2011). Although Sony claimed to be investigating the breach during this time, their complete silence led to a much greater crisis.

During the crisis event the role of ethical leadership is even more important. Not only should they be the ones persuading others about the severity of the issue but they should also be the party responsible for speaking for their organization. By being the voice of their group they are accepting responsibility and making sure that the organization's message is clear and accurate (Johnson, 2012b). The BP Deepwater Horizon oil crisis serves as an example of how this stage can go astray. First, BP had not planned for a crisis event and was in fact functioning day-by-day in response. BP did not have an identified spokesperson and their CEO, in what was perceived as arrogance and negligence, provided unethical leadership ethical (Mejri & Daniel, 2013).

In the post-crisis stage the image of an organization usually suffers as blame is placed on it for its failures throughout the process. The role of the ethical leaders is multiple at this stage. They must not only help to rebuild the organization's reputation but also promote healing within and outside their organization. This involves communicating clearly with all parties about what has happened and identifying how the organization will correct its mistakes. In order to correct its mistakes, the ethical leader must lead the organization in learning from the crisis situation. Leading the organization through analyzing its practices that worked and those that failed and making sure corrections are implemented are all part of the role of an ethical leader (Johnson, 2012b).

The role of an ethical leader during the stages of a crisis are paramount in an organization leaving a situation stronger and still well perceived in the eyes of its stakeholders and the public. An ethical leader must make sure their organization not only plans for crises but responds in a way that is transparent to the community, takes into consideration those impacted, and places the blame in the right places.

Ethics Officers offer all organizations not only leadership, but also strategy (Trevino & Nelson, 2007) for ensuring both compliance and communication of the company's standards on ethics (Stanwick & Stanwick, 2014; Trevino & Nelson, 2007). Many companies may hire someone as a "VP of Ethics" or official legal counsel in this type of position; either way, their position can be a lot like that of a Human Resource professional in that they help those within the company with issues, and also deal with issues for the company that may arise. These officers even have their own professional organization called the Ethics and Compliance Officer Association (ECOA), founded in June of 1991 after a meeting of 30 ethics officers at Bentley College. Legislation within the United States, mainly the Federal Sentencing Guidelines for Organizations Act, was also passed in 1991 and credited for encouraging organizations to adopt internal regulations that help them prevent, detect, and report any fraudulent or il-

legal actions. The government also encouraged the hiring of ethics officers within organizations to help them maintain their standards (Stanwick & Stanwick, 2014).

A code of ethics is another tool meant to not only communicate an organization's ethical views and values to its employees, but also to its external relationships (Stanwick & Stanwick, 2014). But what is a *code of ethics*? According to Stanwick & Stanwick (2014) a code of ethics is simply a detailed document of specific ethical standards within an organization. Or as Trevino & Nelson state a code of ethics is your "main road map" or "ground rules" for ethics within the organization (p. 332). Codes are also adopted by professional organizations, social services agencies and schools. Both the New York Stock Exchange and the NASDAQ require all companies listed on their exchanges to have a code of ethics (Johnson, 2012a; Johnson, 2012b). But simply having a code of ethics should not be an alternative to putting an entire ethics program in place within the organization – it is simply one piece (Trevino & Nelson, 2007).

The code of ethics does represent the ethical standards of an organization and must be developed, literally from the inside out. The code then may vary in length depending on content development (Stanwick & Stanwick, 2014). As Ghillyer (2012) points out, it is critical for the firm to demonstrate its commitment to ethical behavior and that dedication should be detailed within the code itself. He further articulates several key factors in regard to an organization's code:

- It should represent an organization's key values.
- It should be a detailed guide to acceptable behavior.
- It can be specific and detailed.
- It can address penalties for violations (p. 196).

Well-written codes of ethics commonly address the following six areas:

1. **Conflicts of Interests:** Employee benefit at the expense of the organization or where employee judgment becomes compromised. An example in STEM is when an engineer takes a "gift" from a company and later signs a contract for purchasing equipment from them.
2. **Records, Funds and Assets:** Companies must submit accurate financial records. Under Sarbanes–Oxley Act, companies must now submit even more detailed documentation.
3. **Information:** Keeping certain company information "private," especially from competitors.
4. **Outside Relationships:** How relationships with suppliers, competitors, and government agencies are handled has both legal and ethical consequences. It is important to avoid behavior such as insider-trading, conspiracy, or price-fixing.
5. **Employment Practices:** This area may deal with such areas as discrimination, sexual harassment, workplace violence, and other related issues.
6. **Other Practices:** This final category can cover a broad range of topics from employee health and safety, the use of technology in the workplace, overseas conduct and global ethics, and the environment (Johnson, 2007, pp. 235–236; Johnson, 2012b). STEM organizations may especially make use of this final area to define many industry-related concerns.

Global Codes of Ethics that are adopted by many multinational corporations contain similar elements and also highlight more international concerns such as human rights, labor standards, the environment, and anticorruption (Stanwick & Stanwick, 2014).

The global financial crises of 2008–2009 and the revelations surrounding the violations of ethical behavior that led to the crises – even after the measures taken 5 to 10 years earlier following collapses like WorldCom and Enron – turned the focus back to the corporate culture. Although most, if not all, companies develop Codes of Ethics, by themselves these codes were often nothing more than another document crossing someone's desk and put on a shelf for safe keeping. The individual, the corporate culture within which they worked, and the interplay of these two with the company's Code of Ethics all impact ethical business behavior (Gino & Margolis, 2012). While individual training around ethical behavior is important to help an individual make ethical decisions (McIntyre, 1991), creating a culture built upon organizational practices and conduct provides the framework for ethical behavior (Johnson, 2012b).

Corporations can develop an ethical business culture most effectively by addressing ethics through various methods. Ethical corporations and ethical climates have:

1. **Ethical Leaders:** The greater the cognitive moral development a leader has the more likely their employees will see them as ethical leaders, follow their example, and build an ethical culture (Jordan, Brown, Trevino, & Finkelstein, 2013). Ethical leaders can come from all levels of the corporate structure.
2. **Ethical Small Group Interactions:** Developing a culture within small groups that create cooperation, self-leadership, sharing of divergent views, active listening, and ongoing dialogue that creates interpersonal and organizational understanding will help to develop ethical culture within these groups and the participants.
3. **Diversity:** Having a diverse workforce provides multiple perspectives to any situation and can lead to smarter and more ethical actions.
4. **Integrity:** Is creating ethical consistency that encompasses all areas. It builds greater levels of trust and allows others to be open and expressive to one another.
5. **Process Focus:** Companies have concern for not only the outcomes but also the means through which they are reached.
6. **Social Responsibility:** The organization creates a climate of caring for things outside of the organization.
7. **Core Values:** The central identity of the organization. These need to be ethically aligned (Johnson, 2012b).

Each of these is just a sign of an ethical company but does not guarantee it. However, when each is in place and continuously monitored, an ethical culture can be created and maintained.

Managing Conflict with Conflict Coaching

A comprehensive review of the literature on civility, bullying, mentoring, mediation, negotiation, conflict, conflict management, and various other strategies revealed there are no fewer than 40 books and manuscripts that address these topics. Conflict resolution had a number of titles aimed at leaders, managers, and supervisors concerned with developing and maintaining an ethical organizational culture and included work by Avruch, 1998; Cloke & Goldsmith, 2005; Deutsch, Coleman, & Marcus, 2006; Goodwin & Griffith, 2013; Masters & Albright, 2002; Mayer, 2004; Runde & Flanagan, 2007; & Van Slyke, 1999. Additional titles on mediation and negotiation included works from Dana, 2001; Doherty & Guyler, 2008; Kritek, 1994; Lax & Senenius, 1986; Ury, 2000; & Warters, 2000. Finally, the relatively new issue of conflict coaching had fewer titles, but very deep potential. More recently, authors including Furlong, 2005; Gerzon, 2006; Goleman, 2002; Lipsky, Seeber & Fincher, 2003; Organ, Podsakoff & MacKenzie, 2006; Salin, 2003; & Twale &

DeLuca, 2008 introduce new concepts including incivility, bullying and emotional intelligence. However, only three authors develop and discuss the concept of "conflict coaching" (Griffith, 2013, Jones & Brinkert, 2008; & Noble, 2012) and the works of these authors are within the last 5 years.

Considering the many potential conflicts that may arise within a workforce, it is clear that the organization has multiple pathways to prevent, resolve, or engage in these conflicts. Griffith (2013) has developed a model that includes the "five lines of defense for managing conflict" rating these lines of defense from least effective to most effective. Conflict coaching then arises from the more effective ways to manage conflict.

Without question, the least effective and least attractive line of defense for responding to conflict is the fifth line involving defending the institution through external agency and judicial proceedings. Of course all organizations, and particularly STEM organizations that deal in patents, research, development, and introduction of new products will have conflicts that reach this level. Customers and employees will pursue external agency and judicial remedies despite the best efforts on the part of the organization to address legitimate concerns. However, the number, intensity, and impacts of lawsuits may be significantly lessened if the organization is making reasonable attempts to use the lines of defense that come before it. If the organization embraces ethical behaviors, creates a vision that stakeholders can buy in to, and lives that vision every day in the form of high-quality leadership actions, then the likelihood of employees using the fifth line of defense is diminished. In many situations, employees may feel they have no other option than to pursue judicial and external agency remedies because other options were not offered, unavailable, or ineffective and unsatisfactory when used.

According to Griffith (2013), the fourth line of defense is the traditional HR employee relations model. In this model, employees know they can rely on HR to facilitate standard grievance and progressive discipline processes, and related investigative and adjudicative practices, to address their conflict situations. While drawing on HR is often appropriate and necessary, conflict resolution is left in the hands of decision-makers rather than those directly involved with the dispute. Unfortunately, when conflict reaches this level, the opportunity for reflection and learning on the part of the disputants is limited or lost altogether. Fourth line responses generally focus on who is "right" and "wrong" and what corrective actions should be taken. No teaching is involved and employees are not held responsible for their own disputes and often no third-party assistance is provided in the process of communication. Often, level 4 disputants simply want the ruling authority to make a decision.

Building Conflict Capability in the Workforce

Certainly, there are more effective means for resolving conflict that do not require the use of formal employee relations' responses or external oversight. Such responses not only have the promise of helping employees resolve their conflicts in a more meaningful and lasting way, but they also provide tools and strategies that educate employees and expand their ability to resolve conflicts on their own in the future (Griffith, 2013).

The lines of defense discussed previously provide little to no opportunity to assist employees to address their own conflicts or to build capability for doing so along the way. Often, these opportunities are a result of managing the conflict through formal channels. Such opportunities are also lost because the fourth and fifth lines of defense generally create a win/lose mindset between the institution and the complaining employee, making processes for addressing conflict situations inherently adversarial. In contrast, the first, second, and third lines of defense present a wealth of opportunities for (1) putting control in the hands of disputants to address their own conflicts, (2)

building capabilities among employees for doing so, and (3) allowing the institution to work with rather than against employees to resolve conflict situations. Opportunities for building conflict-capability are significant (Griffith, 2013).

The best option is for organizations to create an ethical environment where the existence of conflict is minimal. The ethical environment is not totally free of conflict because even the healthiest organizations experience conflict as a matter of course. Conflict is a natural consequence of individuals working together and "bumping" into one another, often leading to synergistic outcomes on the theory that differing points of view, once reconciled, converge into better results than parties in conflict might have achieved on their own. STEM organizations engaging in best practices for effective management and leadership and fostering a civil, collegial, and motivating environment have a higher probability of minimizing conflict and responding promptly to concerns before conflicts evolve or escalate. In this scenario, formal offices like human resources and legal support a conflict free environment by maintaining superior services for screening and hiring employees; providing basic training on supervisory skills and HR/EO compliance; facilitating effective on-boarding programs; conducting and responding to organizational climate assessments; enforcing HR and employee relations policies in a fair and equitable manner; and facilitating diversity, employee engagement, and work/life initiatives.

When the organization embraces the ethical climate and culture in efforts to respond to organizational conflict, opportunities often exist for parties to learn and reflect on the conflicts they are experiencing and to develop the skills and competencies necessary to resolve them individually. According to Jones and Brinkert (2008) this involves willingness on the part of employees and organizational leaders to develop the capability to resolve conflicts through direct means. Of course third-party intervention can be a viable option, but in this model, employees will always be their own best advocates for their situations. They have the skills, the knowledge, and most importantly the attitude to speak for themselves.

The best organizational leaders provide opportunities for employees to develop conflict-resolution skills *before* conflicts arise. Modules on topics such as assertiveness, team dynamics, negotiations, raising difficult issues and having difficult conversations, personality and team differences, and emotional intelligence are just a few of the topics, often called "soft skills" in a STEM workplace, that employers should consider. Training can also include efforts to develop managers, leaders, and others as capacity builders for the employees they lead and manage. For example, rather than calling upon organizational leaders and HR to address conflict situations as third-party mediators, HR can facilitate programs that develop managers, team leaders, union representatives, and others to serve as "in-house" third-party interveners.

Helping employees address their conflict situations in the moment is a huge part of capacity building and a necessary first step for leaders to embrace in conflict coaching. Therefore, leaders and HR professionals need to develop their skills in coaching and consulting with others to help them address conflicts. The topic of "conflict coaching" is relatively new to HR practice (Jones & Brinkert, 2008; Griffith, 2013). Beyond performance and development coaching, conflict coaching involves concrete analysis of conflict situations that employees are facing, examination of the relationship, personality and power dynamics involved, and development of strategies and approaches that the coached employee can take to manage conflict when returning to the work unit. In general, HR professionals must learn how to provide general consultation services to managers and leaders on how to manage team and systemic conflict issues impacting their departments and work units (Griffith, 2013).

The third line of defense involves bringing in outside mediators/facilitators who are not directly

involved in the dispute to assist parties in resolving the matter. Such methods provide numerous opportunities for building capability among disputants to learn from and resolve their disputes on their terms. Mediation is the traditional form of third-party intervention in which an unbiased, neutral representative with appropriate skills and training assists the parties in the communication process (Griffith, 2013). Although some mediations, particularly those within the legal system that are facilitated as a means for settling litigation, can be very formalized and appear to limit the decision-making authority that the parties can retain, mediated disputes in the work context should generally be more relationship focused and should drive as best possible decision-making to where it belongs: in the hands of the parties themselves (Jones & Brinkert, 2008).

Besides mediation, which often implies a two-party dispute, third-party intervention can also include facilitated communication processes involving three or more parties, such as smaller working groups and teams (Kritek, 1994). Third-party interventions can also include consensus-building efforts among and across teams and sustained dialogues involving multiple interventions and meetings to address deeper relationship, environmental and cultural issues. There are many methods by which organizational leaders can support disputing parties by providing third-party assistance or referring them to other appropriate, qualified professionals.

FUTURE DIRECTIONS

Ethics Training

Corporate mission and values statements, codes of ethics/conduct, ethical policies and manuals are simply not enough in today's global business to ensure ethical practices. Organizations that want their employees to practice ethically need to develop and hold training programs for defining ethics within their company as well as identifying ethical issues for their employees at every level – from the lowest worker to the highest manager. But successful training doesn't stop at new employee orientation; it must continue regularly throughout the professional life of the employee and the company. Effective ethics training programs are offered frequently, at regular intervals and revisit emerging ethical topics (Trevino & Nelson, 2007).

There are a number of benefits to conducting effective ethics training programs for employees. According to Stanwick & Stanwick (2014) these include:

- Employee awareness of ethical standards of the firm.
- Guidance on reporting unethical behavior.
- Integrating values systems of top management to other employees in the firm.
- Allowing company to maintain high moral standards regardless of economic conditions.
- Aiding in development of strong employee teamwork and productivity.
- Aiding in strong employee growth and vision.
- Helping to ensure company participation in legal activities.
- Supporting the integration of ethical values into the day-to-day decisions of management.
- Establishing a positive public image for the organization.

Of course, it is critical that the organization not establish an ethics program and policies just to raise the public image of the firm. An ethics program should be an instrument that is used by the organization to ensure that its values and standards are understood by all of its employees and stakeholders outside of the firm as well.

According to Johnson (2012b), effective ethics training programs incorporate four core components:

1. **Focus on Your Organization's Unique Ethical Problems:** The most useful training addresses those issues your employees face daily. What issues do the STEM professionals face in your organization most frequently? Issues as they travel abroad? Vendor issues? Introduce examples drawn from real experiences and equip trainees with the tools they need to handle these issues as they face them the next time.
2. **Allow Plenty of Time for Discussion and Interaction:** It is fine to spend time in the "traditional" classroom setting with lecturing over handouts and PPTs on various topics, but also allocate time for small group or individual discussions, debates, and case study examinations over the topics as well. This gives trainees a chance to interact with one another and essentially allows them to assist each other with the resolutions.
3. **Taps into the Experience of Participants:** Beyond the discussions, ask participants to provide actual situations they have encountered or recent experiences they could share so that the participants become the actual "instructors" providing feedback and insight to each other.
4. **It is Integrated:** Make sure to integrate ethics discussions into other times, topics, and activities whenever possible to provide a solid message and connection to the organization. The stand-alone workshop is fine and does help to send the message, but continuous reinforcement of ethics policies and values whenever possible is best to keep employees engaged with them.

The delivery of effective ethics training has most recently exploded past the popular methods of traditional classroom training using standard lecture, handouts, PPTs, and case studies. Presently we find that companies have become even more creative in engaging their employees while reinforcing their ethical standards. Companies such as Marathon Oil Co. have employed a combination of both old and new techniques with employees signing "commitment cards" for their new code of ethics, but created a video with their own management team explaining the new code of ethics to employees instead of just a standard written document sent out. They also continue to use online training and hold ethics forums to educate their employees on ethical issues (Stanwick & Stanwick, 2014, p. 239).

Lockheed Martin is another example of a more progressive company as they launched a series of video messages several years ago titled "The Ethics Minute" that was sent to employees through their email. These messages communicated a weekly theme that was often tied together keeping employees in suspense until the next video. Lockheed also sponsored an annual video competition titled the "Ethics Film Festival" in which employees could produce a short, two-minute video on their own time over an ethics topic and enter it in a recognition competition (Trevino & Nelson, 2007, p.337). Creative methods to integrate and communicate the firm's ethical values, such as these, are becoming more popular.

Currently, one of the most popular methods to engage employees in ethics training has been the increased use of online education and educational technology. Organizations can employ a partial (hybrid) or full online training strategy, using their company's website to facilitate the training. As Loui (2005) suggested, a variety of strategies may be used within the online environment to engage trainees in the ethics material. Among these strategies are synchronous chats discussing various ethical topics, issues, and case studies actively with each other and the instructor or facilitator; small group discussions broken into smaller chat rooms and monitored by the instructor/facilitator; forum or blog-style asynchronous discussions over topics; and finally, debates or role-playing exercises over ethical issues or dilemmas can be held. Essentially, anything completed in the traditional classroom, with some design alteration,

can usually be accomplished in the virtual environment providing organizations a wide variety of options to integrate and communicate their ethical standards, codes, and policies.

CONCLUSION

As the economic case for the importance of STEM as a wealth creator becomes clearer, it is also becoming clearer that although content area knowledge is important, soft skills must also be considered as important. Too often the climate and culture of an organization erect barriers for STEM workers, especially women and minorities in engineering. It is imperative that organizational leaders understand that an ethical climate is important in retaining STEM employees, and conflict must be dealt with on a daily basis. Conflict is not good or bad, it just is. These skills are transferable to all areas of a STEM worker's personal and professional life, and it is imperative that businesses create a culture that enables employees to embrace expected ethical behavior, and to provide them with the training and professional development to acquire the skills necessary to make a positive difference.

There are many ethical decision-making models, and high-quality professional development can greatly assist STEM professionals, especially those in engineering, to use these models during the workday. Conflict coaching is also a tool available to leaders who wish to empower STEM employees and help them understand how to deal with conflict in the workplace. The delivery of ethics and conflict training has come a long way in the past few years. From online to hybrid to face-to-face delivery methods, the bottom line is that organizations have many delivery tools at their disposal. There is really no excuse for global STEM organizations not to develop and deliver high-quality ethics and conflict training in engineering and other science, technology, and math fields as an integral piece of their organizational climate and culture.

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KET TERMS AND DEFINITIONS

Conflict Capable Organizations: Conflict capable organizations embrace effective means for resolving conflict that do not require the use of formal employee relations' responses or external oversight. Such responses not only have the promise of helping employees resolve their conflicts in a more meaningful and lasting way, but they also provide tools and strategies that educate employees and expand their ability to resolve conflicts on their own in the future

Conflict Coaching: Conflict coaching is organizations making a concerted effort to equip all employees with the necessary skills, competencies, mindsets and dispositions to address their own conflicts and seek third-party assistance when necessary. The organization systematically develops capacity to engage in such approaches to support employee, team, department and overall organizational effectiveness and growth.

Engineering Ethics: Engineering ethics consists of the responsibilities and rights that ought to be endorsed by those engaged in engineering, and also of desirable ideals and personal commitments in engineering. Engineering ethics is the study of the decisions, policies, and values that are morally desirable in engineering practice and research.

Ethical Decision Making: Ethical decision making is a complicated sequences of relational skills that most humans don't often know or understand and a psychological process through which one course of action in particular is morally right whereas another is morally wrong. Ethical behavior is done by selecting the most ethical alternative out of the available options; individuals make decisions under constraints of cognitive and information-processing capability, incomplete information, and the influence of cultural beliefs.

Chapter 16
Software Engineering Ethics Education:
Incorporating Critical Pedagogy into Student Outreach Projects

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ABSTRACT

The difficulties inherent in the nature of software as an intangible object pose problems for specifying its needs, predicting overall behavior or impact on users, and therefore on defining the ethical questions that are involved in software development. Whereas software engineering drew from older engineering disciplines for process and practice development, culminating in the IEEE/ACM Professional Code in 1999, the topic of Software Engineering Ethics is entwined with Computer Science, and developments in Computer and Information Ethics. Contemporary issues in engineering ethics such as globalization have raised questions for software engineers about computer crime, civil liberties, open access, digital divide, etc. Similarly, computer-related ethics is becoming increasingly important for engineering ethics because of the dominance of computers in modern engineering practice. This is not to say that software engineers should consider everything, but the diversity of ethical issues presents a challenge to the approach of accumulating resources that many ethicists maintain can be overcome by developing critical thinking skills as part of technical training courses. This chapter explores critical pedagogies in the context of student outreach activities such as service learning projects and considers their potential in broadening software engineering ethics education. The practical emphasis in critical pedagogy can allow students to link specific software design decisions and ethical positions, which can perhaps transform both student and teacher into persons more curious about their individual contribution to the public good and more conscious of their agency to change the conditions around them. After all, they share with everyone else a basic human desire to survive and flourish.

INTRODUCTION

As a discipline, software engineering grew out of computer science in response to the "software

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crisis" of the 1960s that was characterized by the growth in complexity or criticality of computer applications and the problems of software projects going over budget and time. The need arose to identify processes and methods that could "engineer" software in similar ways as material objects like buildings or cars. Pioneering works of Dijkstra(1968) and Parnas (1972) on programming among others laid out the foundations of development methodologies and early models such as Waterfall and Spiral that borrow from engineering and project management typical practices as requirements, design, construction, risk management, etc. The debates on whether software can be "engineered" are mainly concerned with the difficulties in matching the preciseness of measurements that are found in traditional engineering work (used to describe structures, electronic or mechanical devices). In turn, this drove research on areas such as software metrics and effort estimation that are concerned with defining qualities and quantities for measuring software and predicting cost and time of software development projects (Fenton & Pfleeger, 1997). These difficulties, inherent in the nature of software as an intangible object, also pose similar problems for specifying its needs, predicting overall behavior or impact on users, and therefore on defining the ethical questions that are involved in software development. Although the position of software engineering as an engineering discipline is still controversial (Shaw, 1990; McConnell, 1999; Parr, 2013) and the problems of software projects going over budget and time persist, research on approaches for more rigorous and disciplined practices is still evolving (Schmidt, 2013). These debates, however, are not the focus of this chapter, but the origins of software engineering in computer science and its "transition" into an engineering discipline that are relevant to the development of its professional obligations and ethical codes, as well as teaching approaches.

The fact that software engineering matured in computer science departments rather than in engineering schools, some researchers argue, led to an emphasis on moral or legal abuses committed with a computer in its approach to ethics. However, ethical considerations in software engineering have been evolving over the past two decades from focus on customer and employer to look at societal implications of computer systems. Although it took a century for ethical codes for the medical profession and decades for engineering to consider the social context, the rapid pace of technological advancement and their ubiquitous nature bring new ethical issues more frequently into the lexicon of computing ethicists. Contemporary issues in general engineering ethics such as globalization have raised questions for software engineers about computer crime, civil liberties, open access, digital divide, etc. Computer-related ethics is also becoming increasingly important for engineering ethics because of the dominance of computers in modern engineering practice. In the early 1990s, a different emphasis within computer ethics was advocated by Donald Gotterbarn (1991) who believed that computer ethics should be seen as a professional ethics devoted to the development and advancement of standards of good practice and codes of conduct for computing professionals. He headed the joint task force of the IEEE and ACM that created the code of ethics for software engineers in the late 1990s. The code lays out 8 principal obligations of software engineers to society, client, employer, colleagues, and the profession in the processes they follow and judgments they make to develop and maintain their products (Gotterbarn, 1997).

In class, software engineering ethics, often overlooked, highlights issues of confidentiality, competence, intellectual property, and computer misuse, and introduces the ACM/IEEE Code of Ethics (Sommerville, 2007). Like other applied ethics fields, the case study approach is used for raising ethical questions in the practice of software engineering—looking at extreme scenarios of life and death common for safety-critical systems to milder issues such as time consumption of addic-

tive computer games. Student and teacher ponder the possible implications of their decisions and learn about obligations, gray areas, and trade-offs and discuss ways of resolving the ethical issues that feature in the case study. The class discussions typically touch on personal values such as honesty, fairness, and trust; and on business judgment concerning profit, production, and so on. The assumption is that the "best insurance against unethical activities is for the company, group, or organization to foster an environment where employees feel confident in communicating their thoughts and to ask questions if they feel something is not being pursued in an ethical manner" (Gotterbarn, 2000). Although issues about the global environment and society are implied, the different ethical contexts that a software engineer interacts with such as client, company, industry, as member of the team, family, profession, etc., are generally addressed in the content and approach to teaching software engineering ethics. This led many observers, such as political philosopher Langdon Winner (1990), to critique the preoccupation of engineering, followed for software engineering, ethics with specific moral dilemmas confronting individuals. Different models for a more encompassing ethical analysis have been proposed, such as by distinguishing between micro and macro ethics (Vanderburg, 1995), by including the implications of public policy (Herkert, 2000), or by focusing on "culturally embedded engineering practice," that is, institutional and political aspects of engineering, such as "contracting, regulation, and technology transfer" advocated by (Lynch & Kline, 2000). This trend is also evident in the inclination by accreditation programs to promote a broad education and seen it as necessary to understand the local and global impact of engineering solutions on individuals, organizations, and society (ABET, 2014; ACM/IEEE-CS, 2014).

This chapter proposes concepts from critical pedagogy—a method for figuring out how to bring the specific context to life (Hale, 2014), for developing the understanding of the impact of software business or engineering decisions on broader ethical issues such as human rights and professional aspirations for doing social good. The first section puts in a historical perspective, developments in the field of software engineering ethics, and the second section highlights commonly used approaches for teaching the topic. This is followed by a discussion of pedagogical tools that are proposed for assisting software engineering students to observe the social, environmental, and economic contexts of their solutions. The final section concludes with emphasizing the relevance of these approaches to ethics education, especially for developing countries though software knows no border.

COMPUTER, INFORMATION AND SOFTWARE ENGINEERING ETHICS

As software engineering drew on general engineering for process and practice development, culminating in the IEEE/ACM Professional Code in 1999, the topic of Software Engineering Ethics cannot be separated from its origins in Computer Science, and developments in Computer and Information Ethics (Bynum, 2011). Some of the early work on computer and information ethics is attributed to Norbert Wiener (1948) during World War II, who also founded the field of cybernetics and considered the social and ethical implications of electronic computers. Wiener predicted that, after the war, the world would undergo "a second industrial revolution"—an "automatic age" with "enormous potential for good and for evil," that would create many new ethical challenges and opportunities. He explored some of the potential effects of information technology on key human values like life, health, happiness, abilities, knowledge, freedom, security, and opportunities, where he argued that societies "must provide a context where humans can realize their full potential as sophisticated information-processing agents,

making decisions and choices, and thereby taking responsibility for their own lives" (Weiner, 1948).

Studies by Walter Maner of ethical problems "aggravated, transformed or created by computer technology" led him to design an experimental computer ethics course for students in university-level computer science programs. Sometimes the addition of computers, it seemed to Maner (1996), actually generated "wholly new ethics problems that would not have existed if computers had not been invented." This view was contested by Deborah Johnson (1997) and others who argued that computers do not generate ethically unique problems but merely "pose new versions of standard moral problems and moral dilemmas, exacerbating the old problems, and forcing us to apply ordinary moral norms in uncharted realms". She agreed with Maner that computer technology generates new specific ethics questions—for example, "Should ownership of software be protected by law?" or "Do huge databases of personal information threaten privacy?" Nevertheless, she maintained that such questions are simply "new species of old moral issues," such as protection of human privacy or ownership of intellectual property, and not "wholly new ethics problems requiring additions to traditional ethical theories." Moor (1985) provided another account of ethical issues in computing in his paper "What is Computer Ethics?" where he discussed why computing technology raises so many ethical questions compared to other kinds of technology. One explanation was that computers are "logically malleable," which makes it possible for people to do a vast number of things that they were not able to do before. As no one could do them before, he reasoned, many ethical questions never arose and therefore, laws or standards of good practice or specific ethical rules were not established to govern them. Moor called such situations "policy vacuums" and held that some of them might generate "conceptual muddles." Another significant contribution to the ongoing "uniqueness debate," reinforcing Maner's claim, came from Krystyna Górniak-Kocikowska (1996), who argued that "computer ethics eventually will evolve into a global ethic applicable in every culture on earth" in a way suitable for the Information Age and the global nature of the Internet.

In addition to the development of the software engineers' ethical code, the 1990s also witnessed other important developments such as the information ethics theory of Luciano Floridi, the "Flourishing Ethics" (Floridi, 1999). Floridi argued that computer ethics should cover much more than "simply human beings, their actions, intentions and characters" and offered his theory as another "macroethics" applicable to all ethical situations and as complementary to traditional Western theories. His approach treats everything that exists as "informational" and therefore having the "right to flourish." He calls the totality of informational entities "the infosphere" where if an entity suffers "entropy" or damage, the result is a partial "impoverishment of the infosphere." With this interpretation of the world—all that exists is "informational" with some moral worth, he argued that the focus of ethical attention shifts from "evil" or "entropy" to emphasis on "preserving and enhancing the infosphere." More recently, a multidisciplinary team proposed "Survival Ethics" (Verharen, 2011) that uses an evolutionary explanation to examine ethics systems from Western philosophy as well as from ancient Egypt and Ethiopia. In this view, the basic value "Survival" is considered "as the precondition for the exercise of all ethical virtues" from which "flourishing" (our right to flourish after being) and "rationality" (as humans) are derived. Still a developing theory, its application to science and technology education, especially one that involves community-based projects (such as Engineers Without Borders), have been examined in different parts of the world (Verharen, 2012).

Beginning with the predictions and computer ethics work of Norbert Wiener and ending with Floridi's "Flourishing" and Verharen's "Survival" ethics, a common concern runs through computer

ethics, namely, protecting and advancing central human values. Over the years, examples of problems that have attracted research and scholarship in computer ethics include: Computers in the Workplace; Computer Crime; Privacy and Anonymity; Intellectual Property; Professional Responsibility; Globalization; Social Implications of the Internet; Philosophical Foundations; and the Metaethics of Computer Ethics (Bynum, 2011). Many ongoing developments in engineering ethics education have been influenced by developments in international standards such as the increased attention to the ethical responsibilities of engineers and the societal context of engineering. For instance, a minimum of three contact hours of material directly related to social context were introduced into the curriculum in the 1998 ACM IEEE Computer Science guidelines—known as EC2000 (ABET, 1998). The issue in this chapter, as Kreiner & Flores (2004) put it, "is not whether ethics can be taught but more importantly what is the method that will best result in teaching the young what they need to know that ensures they will be ethical and act morally. That is the real issue."

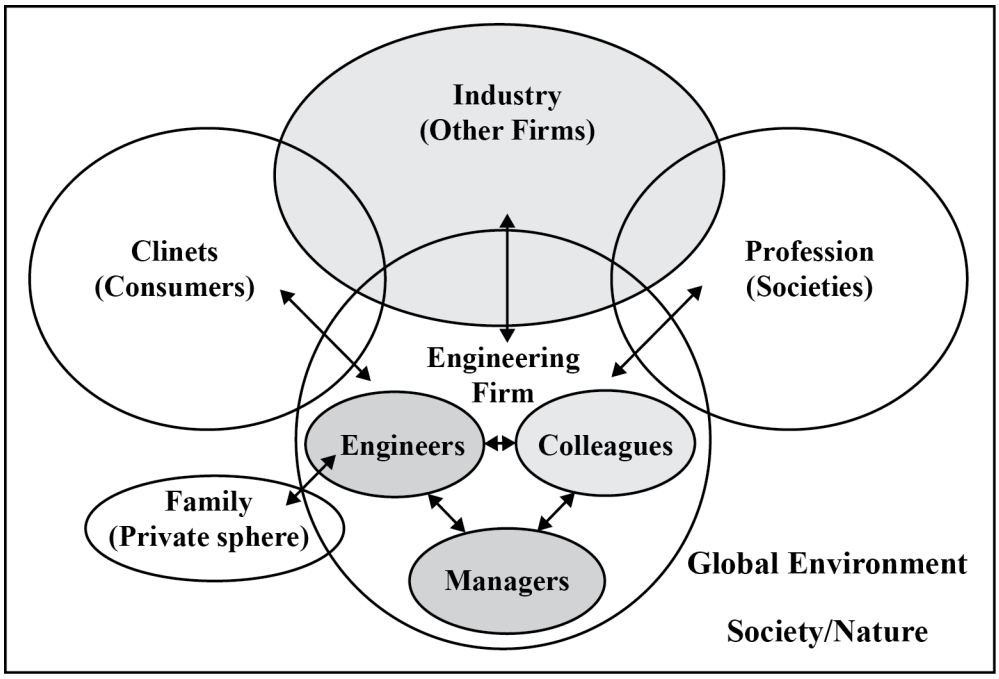
Content and Approaches of Software Engineering Ethics Education

The growing and dynamic role of software applications in different sectors inevitably places a significant burden on the software engineer because of the potential of doing, and enabling others to do, "harm" or "good," as well as requires professional codes that are "adaptable and relevant to new situations as they occur" (ACM, 2014). The ethical frameworks for teaching software engineering ethics have traditionally included engineering codes of ethics and the application of moral theories to examine ethical issues that arise within the professional interactions of the software engineer. For instance, an ethics course at Mälardalen University in Sweden was developed using Moor's concept of "Logical malleability" to examine the interactions and different contexts (Figure 1) of the software engineer within and outside their immediate environment (Dodig-Crnkovic & Feldt, 2009). The course topics, intended for undergraduate students, included issues such as privacy and security, arising from computers data and communication capabilities, and extended the software engineer's concerns into rights-based ethical questions on power distribution, equal opportunities, equity, fairness, justice, gender, and digital divide.

Often courses include case studies, which are becoming popular in teaching engineering ethics (Harris, 2000). Cases come in different sizes and content, they can be long or short, real or fictional, technical or non-technical; they may be available in various forms, in print, online, multimedia, etc. Most cases are self-contained, but some include documentation, such as book chapters (and sometimes entire books), journal articles, news accounts, and primary source archives. Case methods have several common characteristics according to Davis (1999), such as encouraging students to express ethical opinions, identify ethical issues and formulate and justify decisions; in addition to developing their "sense of the practical context of ethics." A number of high-profile cases such as Shuttle Challenger in 1986 are usually included along more of the typical ethical dilemmas encountered by most engineers. Several ethicists, most notably Pritchard (1998), have called for the development of more cases that focus on "good works," that is, cases that demonstrate that "making sound ethical judgments need not end with whistle blowers being demoted or fired". In addition, resources for software engineering ethics education have increased considerably and different curriculum models were developed that vary from required courses or by spreading ethics instruction throughout the engineering curriculum, to integrating ethics topics into Engineering, Technology, and Society courses (Herkert, 2002).

Although many changes have been made in engineering education in the past two decades,

Figure 1. **Contexts of professional ethics (***Reproduced from Dodig-Crnkovic, 2003)*



such as a growing awareness of the importance of ethics and social responsibility to engineering, and a greater drive to broaden the scope of ethical considerations (e.g. including case studies of good works), it remains to be seen if required courses in engineering ethics will become the norm as typical ethics training is still confined to a topic within the software engineering course—more so at universities in developing countries (Ume & Chukwurah, 2012; Shrum & Shenhav, 1995). There is pragmatism among many researchers about the unlikely prevalence of required ethics courses, and a continual call upon faculty to ensure ethical training is included and that "critical thinking skills are developed in the context of technical courses" (Herkert, 2002). Much of the literature that emphasize the role and impact of engineering on society as a whole, however, seldom addresses how that role can be played apart from professionalism. Professional codes, mandatory and dominant in engineering education, are argued in this chapter as insufficient for "the enormously complex moral issues that confront engineers [that] cannot be resolved simply by codes of good professional behavior (engineer to engineer and engineer to employer), important as they are. Engineers must also have a sense of the profound implications those issues have on our society, and on our species." Without such an understanding, some argue "engineers risk floundering in a sea of moral dilemmas and ambiguities that can distort the immense power humans have achieved through engineering" (Bugliarello, 2002).

Can the students develop the required critical understanding through the training provided? Would it raise their curiosity to seek or develop approaches or technologies that are more socially just, that do not replicate power structures that privilege certain groups over others, that are more democratic or responsive to the needs of groups currently marginalized or ignored by science (Harding, 2006; Mayberry, 2001; Frickel, 2010)? How do the issues of illiteracy, poverty, conflict or diversity, prosecution or freedom of expression,

affect engineers' decision-making? What about the dual role played by software in that it delivers the computing potential embodied by computer hardware or a network of computers that are accessible by local hardware, make software an information transformer likely to produce, manage, acquire, modify, display, or transmit the information. How do these transmissions change the receiver or the context in which the information is interpreted? Are software engineers obliged to consider the potential transformations (or consequences) on receiver, context or the information itself, of the software they develop? Should they be concerned about the needs and capabilities at the receiving end as merely a human computer interaction issue? What does "public interest" mean for a software engineer in practice? Who is the public? Do these questions raise further ethical issues for software engineers working in developing country contexts, as consumption for example may raise for developed countries?

Different ideas on incorporating critical thinking skills in software engineering can be found in curriculum development efforts such as the "learner-centred education," which involves identifying critical skills that are associated with software development and searching for the relevant learning resources. This process is seen as emphasizing the "needs, skills and interests of the learner rather than the organization of curriculum content" (Seffah, 2002). An experimental course developed by Narayanan & Vallor (2014) proposes five "Ethically Constructive Habits of Mind and Action" such as self-reflection and looking for role models, for linking the professional, and private, lives of the software engineer. Other researchers considered critical pedagogy as their teaching philosophy (Ibrahim, 2007), or as enabling tools for "students to make the epistemic transformations" to change rather than adapt and survive in the situation (Riley & Claris, 2009).

Critical Pedagogy for Software Engineers

Researchers interested in student–teacher relationships and autonomy of students often explore the field of critical pedagogy, in particular by academic programs in social sciences that involve topics on consciousness-raising, collaboration, coalition-building, social movements, etc. such as women and ethnic studies, and within the discourse of international development through tools like REFLECT[1] that link learning to empowerment. Critical pedagogy is based on Paulo Freire's ideas of education involving the struggle for equity and justice, and his experiences with Latin American peasants. In his classical book Pedagogy of the Oppressed, Freire (1971) connects the educational process to the broader socio-political context that, he argues, would transform the classroom into an agent of social empowerment and action. He acknowledges the need for students to rigorously prepare for the world as it is, but sees educators as equally and ethically obligated to deliver the curriculum and at the same time raise critical questions about it. He argued that this approach would prepare students to struggle for the world as it could be by introducing them to a contradiction that challenges them epistemically and helps them "understand what contradiction means, that human action can move in several directions at once, that something can contain itself and its opposite also" (Shor & Freire, 1986), a contraction he states, makes one fall into "hypocritical moralism" (Friere, 1998).

In the following subsections, two experiences at computer science departments, in the US and Sudan, are used to discuss critical pedagogies application as a complementary tool for software engineering ethics education. The two experiences are supposed to be typical of teaching innovations meant to connect learning with context. The first is a curriculum development exercise at Rice and Sunny Buffalo Universities in the US, in collaboration with Microsoft; the second is a project at

University of Khartoum and Sudan University of Science and Technology, in collaboration with UNICEF. Although these experiences did not focus on ethics education per se, as case studies do, both experiences involved an ethical analysis component. The experience at Buffalo and Rice universities included an evaluation of the social and ethical aspects of the solutions that the students developed. By the same token, the experience at Khartoum and Sudan universities started by commitments to the ethical principles of the institutions involved and the Software Engineers Code of Ethics, in addition to a set of considerations typical of teamwork dynamics. During the course of the projects, the students discussed development problems and the possible improvements that a little technology with their energy and capacity can bring to the quality of life of an elementary school student or a newborn in a rural village. The experiences did not begin using critical pedagogy, but rather created the conditions where critical pedagogy can be applied (i.e. used to interrogate the engineering decisions made by the project), in an attempt to learn about the kinds of ethical questions that can be raised about the "harm" or "good" that can result from engineering work and to discuss their utility for ethics education.

The Experiences from the US and Sudan

The narratives below give a brief description of the two experiences that will be discussed in terms of five basic critical pedagogies (Hale, 2014) using literature on the first experience and the author's personal experience with the second. These descriptions intend to highlight ethical issues that exist in this form of training and that can serve a dual role, first as a service learning exercise found in some engineering schools, and second as hands-on ethical education.

Rice and Sunny Buffalo Universities

The term "socially relevant computing" was employed by researchers at these two universities in the US, in collaboration with Microsoft, as an approach to constructing computer science (CS) curriculum, and a way to "reinvigorate interest in computer science" (Buckley, 2008). Their work was mainly motivated by the lower enrolment rates[2] in computer science degrees at US universities in comparison to other fields and hypothesized lack of social relevance in undergraduate computing courses as one of the possible explanations. The assumption was that US students are more attracted to social sciences as opposed to computing sciences partly (they hypothesized) because of a desire to have a societal impact. The new approach, SRC, aimed to inject the curriculum with material that promote CS as a tool for solving personal problems (socially relevant with a small "s") and for solving problems of societal concern (socially relevant with a capital "S"). As a result of this research, Sunny Buffalo introduced a project where software engineering students develop a software solution for a real-world problem, a solution that is then used by students of hardware/software integrated systems to implement a hardware device that realizes the software solution. One of their products, with Microsoft's support, is a communication device that enables "disabled persons to talk." That device was later turned into an educational aid for handicapped children. At Rice, social relevance was introduced differently through a new course on hurricane risk assessment and evacuation policies. This course was delivered by an interdisciplinary team from the departments of computer science,[3] political science, civil and environmental engineering. The project teams, composed of students from these different departments, used their combined skills in data mining and modeling, and in conducting the various structural, social, economic and environmental assessments to develop tools to support evacuation planning, for example, tools

for producing information on numbers of people to be evacuated and their location, mapping evacuation routes and destinations, and simulating the impact of specific evacuation decisions.

It remains to be seen if these efforts at Rice and Sunny Buffalo will have an impact on increasing student enrolment rates in computer science degrees in the long term. However, preliminary results showed that the project helped in retaining students "who were at academic risk or even considered switching majors […] because they wanted to see these projects to completion" (Buckley, 2008). According to Buckley (2009), support provided by Microsoft Research allowed the center to add more software applications in response to direct requests from the community. Some researchers challenged Buckley's recommendations and found that games and not humanitarian projects ranked top in the assignments preferences of their students (Rader, 2011). Whereas others[4] explored the approach of socially relevant computing with a similar vision to Buckley's such as the University of North Carolina at Charlotte and Howard University, or as part of their community engagement initiatives, for example at the College of Science, Engineering and Technology, University of South Africa (UNISA).

Khartoum and Sudan Universities

The University of Khartoum and Sudan University for Science and Technology used UNICEF's Innovation Lab model and its approach to "Technology for Development" developed and established in countries worldwide. The aim of the lab according to UNICEF is to create "a physical space that allows for collaboration among academia, government and non-governmental organisations, and the private sector" that can "become national facilities for building local technological capacities to support humanitarian development efforts" (UNICEF, 2012). The model follows a trend[5] of creating collaborative spaces in development agencies (e.g. the UN's Pulse Labs), in businesses (e.g. Google Labs), and more recently in academia (e.g. Enterprise Lab). Currently, the UNICEF Innovation Lab Network has 13 labs at different stages of establishment, 7 of which are in Africa. The labs engage in different projects according to the context in which they are established. For example, the Copenhagen Innovation Lab, where UNICEF's Supply Division is located, focuses on operational research to improve supply chain management processes, whereas Kosovo Innovation Lab, in a country with a large young population, is focused on youth development programs. The Uganda Innovation Lab is the most established among those in Africa and is engaged in software (service) and hardware (product) development. One of the successful innovations at the Ugandan Lab led to a nationwide adoption of a mobile technology-based birth registration system. Another successful innovation, their "digital drum," is a robust computer enclosed in metal cylinders. It won a place on the 2011 Times Magazine Best Inventions. However, the greater part of UNICEF's innovation work focuses on information and communication technology (ICT) utilizing RapidSMS,[6] which is an open source software providing real-time data collection and analysis capabilities via mobile phones. Innovation projects in a number of countries were developed to improve information flows and access in different problem domains, for example vital records registration (birth and death), pre- and postnatal care, child nutrition, etc. Using RapidSMS and working through software engineering processes, the project team at Khartoum developed a monitoring system for school kit distribution and the team at Sudan developed a routine-vaccination monitoring system.

The primary goal of this project was to examine the efficacy of the innovation lab model in improving the accessibility of UNICEF Sudan Country Office and their government partners to local human capacity in higher education institutions, and in providing a capacity-building environment where students can interact with real-world

problems and stakeholders. The evaluation of the project was therefore twofold, firstly, in terms of the functionality and quality of software applications, and secondly in terms of students experience and learning outcomes. The rate of accomplishment of functional requirements in the developed applications is about 80% for the School Kit team and 60% for the vaccination team, of the total functionality specified at the start of the project; and quality assurance processes that followed relevant software engineering standards were performed for the various outputs (e.g. design, code, testing, etc.). Students' perspectives on their experience and evidence for capacity building were collected using online self-assessment forms and results showed a trend of increased learning for new (such as Python programming language that is not taught) as well as for familiar topics (SCRUM that is taught as part of Agile software development methods). The project evaluation revealed the potential of the campus lab and resulted in agreements between the UNICEF and the two participating universities.

Although the specific outcomes of the projects in the US or Sudan may seem unrelated to the focus of the chapter, it is the trend they reveal among student participants that is relevant for the application of critical pedagogies discussed in the following section. The kinds of development challenges that underpin Technology for Development work appeal to a considerable proportion of young people. This is evident, at least in Sudan, by the high levels of social activism and number of youth groups and networks who are doing humanitarian work (Hale, 2013). In both experiences, teachers involved reported[7] the enthusiasm and interest of the students. A Sudan University student felt that the project "gave me a chance to give back a little of what I have been taking for five years from the university." This is corroborated by a Sunny Buffalo student[8] who thought that the socially relevant computing classes are "a lot more interesting because we get to create real software that can make someone's life dramatically better."

THE CONDITION CREATED FOR CRITICAL PEDAGOGIES

As mentioned, the university experiences are used to explore whether they can create the condition for the application of critical pedagogies in software engineering ethics education. The tenet of critical teaching practice is that it "involves a dynamic and dialectical movement between doing and reflecting on doing" (Freire, 1998). But reflection requires a "personally meaningful and engaging experience" according to Dewey[9] (Riley, 2009). The involvement of the student, directly, with the context and users in the engineering problem, can generate the movement between "doing and reflecting" that allows for the exercise of "critical thinking" skills—seen as essential for applying, and acquiring a broad understanding of, professional ethics (Herkert, 2002, Kreiner, 2004). The practices discussed later include some of the common critical pedagogies in social science research (Hale, 2014). They are, Hale notes, also similar to practices used in "feminist collaborative art projects or guidelines for small-group dynamics in peoples' movement(s)" and "all begin with trust and mutual respect."

1. Generating the Student as Subject and Knowledge Producer:

The course at Buffalo incorporated both problems of personal relevance to the 18–22 year olds e.g. weight management, and problems of relevance to the communities in which students live. It engages them in creating practical solutions (producing tools and devices). The experience with developing a talking device for a stroke patient or communication devices for medically frail children, was found to allow students to see themselves as participating (subjects) in a larger community. This was evident in the Sunny Buffalo student's reference to "someone else" and of another's[10] who liked "the challenge of being given these development tools and having to figure out on

my own how to design an application that works" and thought the "experience will make me a better computer engineer in the end." The experience of students in the Innovation Lab involved using open source software and basic mobile phones to provide real-time data collection and analysis capabilities for remote areas in the country. The specific constraints such as language, infrastructure, etc., required students to examine what they know, gaps in their knowledge, and learn in groups, to design solutions that fit the desired needs. Training being a central goal and the foremost benefit expected from campus innovation labs in general, learning was assessed using a pre- and post-innovation development questionnaire as well as several knowledge management applications such as capturing lessons learned and developing a skills database. At the start of the project, students' ratings generally leaned toward scale levels that indicate less knowledge about an area (null to some familiarity). For example, whereas the majority of team members had almost no knowledge about Technology-for-development concepts and RapidSMS tools like Python programming language and Django framework, they were familiar with SCRUM development method and Ubuntu operating system. Toward the end of the project, self-assessments showed a trend of increased learning for new as well as familiar topics. For example, whereas a proportion of members thought that they know Django well at the end of the project, the proportion of those who knew SCRUM well before the project doubled by the end of the project. Students also reported a sense of achievement and satisfaction at serving the community. The project touched on the CS/IT curriculum on broad subjects such as software engineering, database management systems, knowledge management, and specific areas within these (agile methods, UML, relational databases, etc.), as well as dealt with a popular final year project topic (mobile applications). It is evident from self-assessments that team members built on what they already knew about, and learnt "new things" as put by one "I like the Innovation lab in everything. Because it gave us a chance to be a creative thinker, and help us to learn new things, and make ourselves stronger by using self-reading and self-studying and self-learning. And also let us know new people and work with people and developers around the world."

2. Situating Ourselves in the Context:

Both examples involved students in site visits to gain an understanding of the context. For examples, the students from Buffalo worked closely with the stroke patient, and visited the Handicapped Children's Learning Centre, whereas the innovation lab teams visited the school kits warehouse and vaccination center. The societal value of the projects brought a sense of moral obligation to follow best practices in software engineering processes, to develop systems that fit user needs and context, as well as knowledge of own privileges. The innovation lab work, based on concepts of technology for development (shown in Figure 3) highlights the principles of innovation work at UNICEF that formed the basis of group discussions at the start of the project and was assimilated in their subsequent development work.

The principles include a number of issues that require conscious decisions by the software developer to select the right platform and interface to produce usable software. For example, although implementation for a smartphone platform is appealing because of the functionality it can provide, the choice of basic phone and simple SMS technology can better reach the end user community. Facts on Sudan's telecommunication coverage, mobile phone ownership, literacy rates, etc. prompted students to think outside their urban environment and explore creative solutions to best utilize the existing infrastructure and users' capabilities.

Table 1. Guiding principles of UNICEF's innovation work (UNICEF, 2012)

User-Centered and Equity Focused
• Respond to user needs, be context appropriate, and design collaboratively with end users. • Develop incrementally, using iterative user testing and modifying as appropriate. • Design for the most difficult to reach first, and build solutions that can go to global scale.
Built on Experience
• Build upon previous experience and incorporate best practices into the design of products, services, and processes. • Make knowledge and experience gained around the innovation publicly accessible and prioritize openness as an approach to solving problems.
Sustainable
• Be viable in the long term, factoring in support infrastructure, maintenance, and running costs. • Involve governments in the development of solutions. • Encourage the involvement and training of local experts (technical and otherwise).
Open and Inclusive
• Build technology that is free and open source so that it can be shared with interested parties and adapted by others. • Facilitate access to information. Documentation, content and learning can be shared and accessed by anyone.
Scalable
• Be replicable and customizable in other countries and contexts. • Factor partnerships from the beginning and start early negotiations. • Look toward locally available technologies and use what already exists in the ecosystem.

3. Fusing Teaching with Consciousness Raising:

The students at Buffalo and Rice invented things that apply outside of their circle of friends and fellow students, and the prospect of making a difference sustained and motivated them according to Buckley's account of the experience. "These projects have showed us that when students are passionate about the work they're doing, they will excel," says one of the capstone course instructors, who also observed that the students "recognize that long after they finish a project, real people are continuing to benefit from the technology." The concepts of Technology-for-Development allowed students to consider several issues in software engineering and their relationship to humanitarian development work, for examples, user-centered design and the promotion of values like equity and inclusive development; reusability and open architecture and how they are related to sustainability in limited-resource settings and possible because some code is freely available, which also raised personal questions about the student's position from open source development and whether they would become contributors as well as users. The teams also agreed on a set of values and principles that incorporated software engineering code of ethics, and those of the University and UNICEF, and built consensus on the ethical considerations[11] for teamwork.

4. Building on Each Other's Ideas and Work in Collaboration:

The socially relevant computing involved group work and students from different disciplines. Whereas communication devices were jointly developed by software engineering and electronics students, the hurricane evacuation project involved students from different engineering and social science fields. The innovation lab groups simulated software development teams and split along the phases of software development. This was achieved during the first month (Team Preparation Phase) of the project using group learning

and consensus building. The students' output of this phase, in addition to the requirement specification document, included learning resources for the various knowledge areas and technologies related to the project, templates for software process documentation, and a terms-of-reference document that included project management aspects such as project milestones and deliverables, roles and responsibilities of team members, and ethical considerations. Figure 2 shows the agreed workflow between team members involved in the different software development processes, which highlights the interdependency of the work of analysts, designers, coders, etc. and the professional obligations toward colleagues such as the quality of intermediate products.

During the course of the project, the teams encountered various challenges due the voluntary enrolment and informal setting of the pilot. Some of the strategies adopted by the teams to overcome problems of number shortages when they occurred or technical deadlocks involved restructuring of teams, establishing an in-team technical support role to focus on researching technical problem solutions to share with the coding team. The teams also worked across campuses to share skills that lack in their curriculum but taught in the other campus during the preparation phase; and solutions to technical problems during the development phase. During testing and quality assurance of code and documentation, the sub-teams from each campus served as the external review committee to mimic independent assessments recommended in software engineers' best practice.

5. Encouraging Students to Use Their Knowledge in Everyday Life:

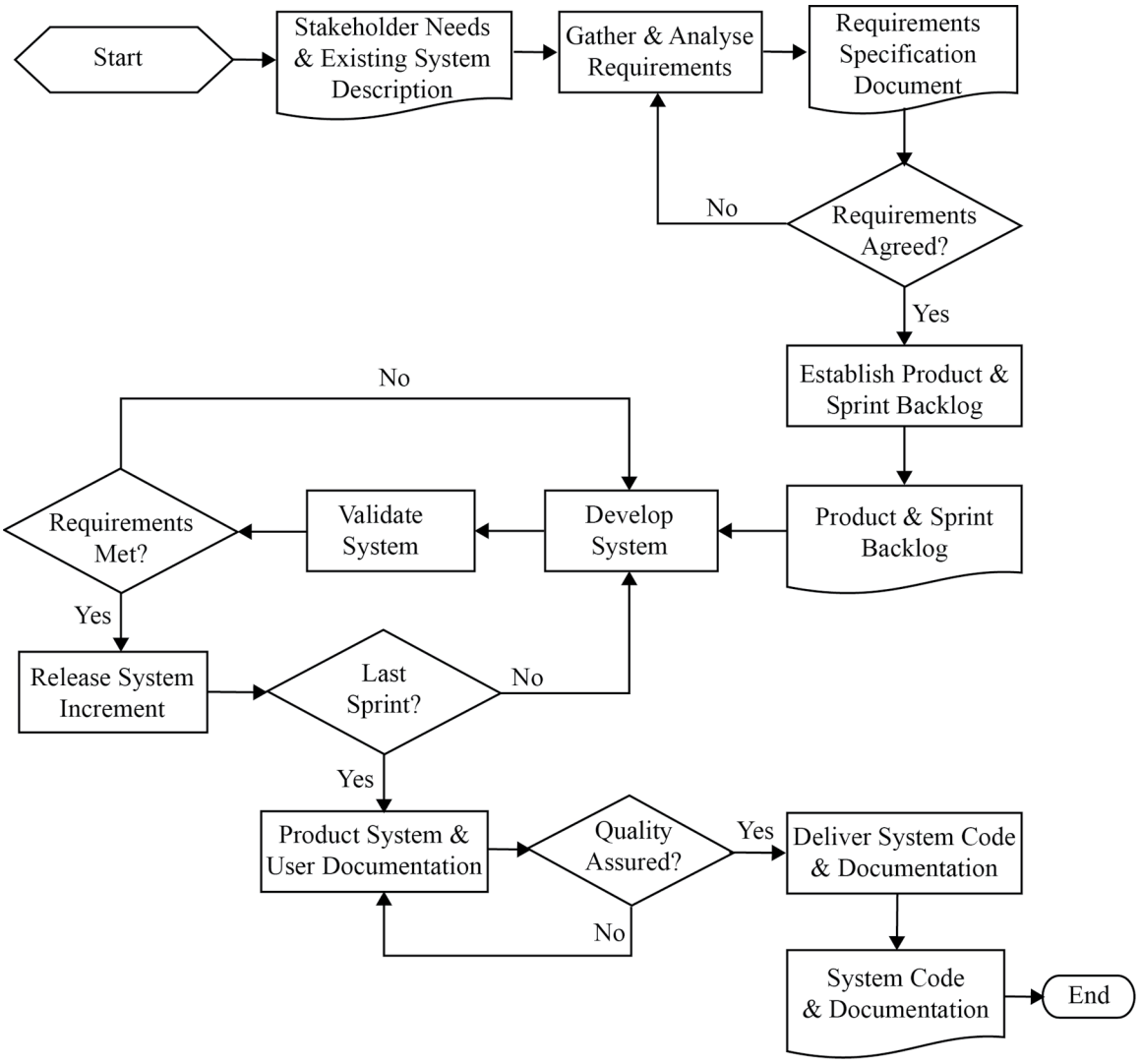
The Sunny Buffalo experience involved developing course material on how mathematics can be used to interpret and better understand everyday events. Students explored programming topics through examples selected based on relevance and impact. Among topics were array using air pollution, sorting using mp3 jukebox. The innovation lab teams were encouraged to use their existing knowledge to learn (and teach each other) the new development tools. During the first month, the students worked in groups to develop expertise required for the project and form their development teams. According to the student's interest, she or he joined one of the working groups that involved individual research and knowledge sharing sessions. Figure 3 depicts the team structure that was generated from this preparation phase.

The three initial groups included: the "related work" working group, which developed into the requirements team, focused on technology for development concepts and the range of development problems addressed by innovation projects; "RapidSMS" group (the coding team) studied the architecture, functionality, associated technologies, and the different implementations of the open source software; and "SCRUM" group (the project management team) used their class notes on agile software development methodologies and practiced the SCRUM method. Through the group work, the students identified their areas of strengths and role in the team, and realized how learning something "new" links to knowledge acquired in school, e.g. learning Python from Java. The discussions of technology for development explored applications in other areas and how some problems they see around them can be solved using the students' new knowledge.

ETHICAL RELATIONS BETWEEN CRITICAL PEDAGOGY AND CASE STUDY

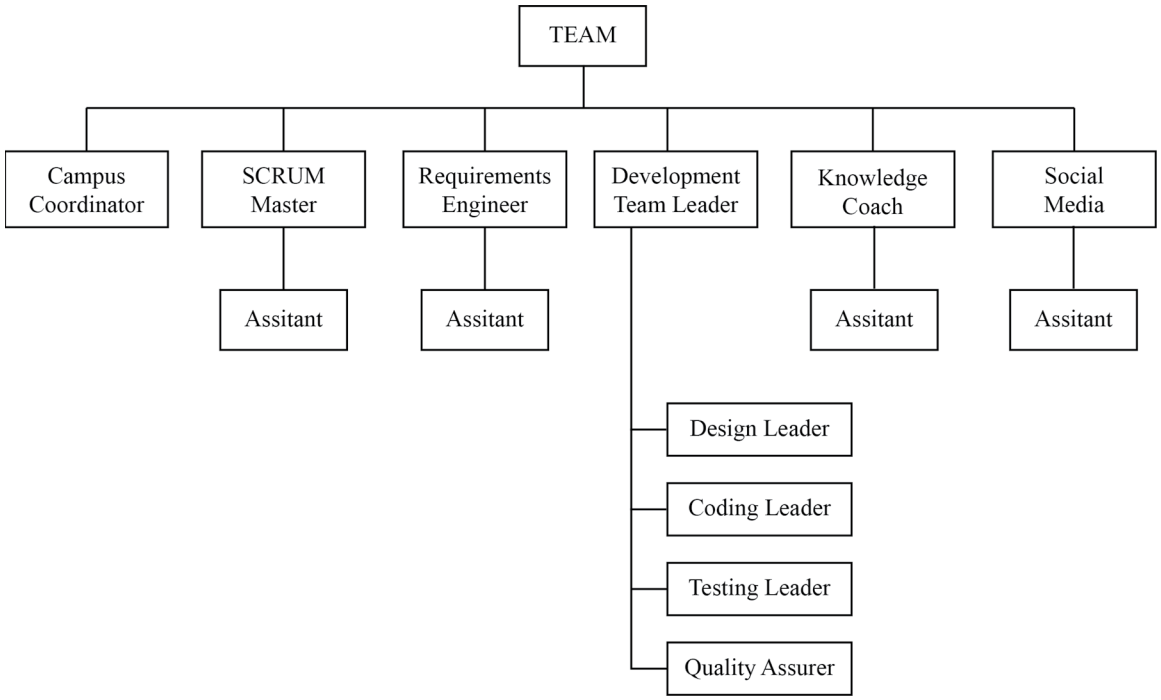
Primarily, the difference between critical pedagogy and case study is that case studies cover a diverse set of ethical questions in which the students must imagine involvement, whereas the university experiences generate the student as the subject of an actual ethical issue. The early exposure to the questioning of engineering deci-

Figure 2. Innovation Development Work Flow



sions, as the student is making them, in terms of the micro and macro impact of their solutions facilitates the understanding and internalization of professional codes that can be viewed as static by the majority of engineers who do not have the opportunity to take part in their development, as well as integrates with other forms of ethics education and outreach students projects. The university experiences exposed students to a typical software development environment and the different ethical contexts proposed in Dodig-Crnkovic & Feldt (2009) where issues may arise with clients, team members, collaborating bodies, and so on. It also showed how their early outreach could have an impact on the image of their profession when they extend outside their immediate circles and connect to different contexts and kinds of users. Examples of ethical issues in the two experiences are split in the following table to address first the question of what "harm the software engineer can be responsible for" that led to class discussions about whether there is an obligation to prevent it; and second, to reflect on the less common question about which decisions can lead to a "contribution

Figure 3. *Innovation lab team structure*



to the good life for others" and the formulation of "good works" case studies.

Some of the questions that can arise during these experiences are fundamentally about what sort of coding practices can prevent the possible harms in Table (2) or can result in more good from the applications? Is the software engineer obligated to develop a code that can be implemented on cheaper or open architecture devices? Should code documentation, user involvement and training, technology transfer issues, be considered in ethical evaluations? Which contradictions are in play if users are dependent on external entities to sustain services? Does the responsibility of the engineer extend to consider disadvantaged users or settings to develop or recommend inclusive alternatives?

There are various examples that can be drawn from the university experiences to illustrate how some of these issues might be handled. For instance the exposure of the students of the "socially relevant computing" class to the real users who will be impacted by their work, whether this allowed them to internalize the experience and "ensure that the devices developed were truly useable" as argued by the course designers at Buffalo and Sunny universities. Similarly, the "Innovation Lab" students considered alternative interface designs to accommodate non-literate users (e.g. using voice or symbols in text messages), and discussed the kinds of new jobs that can emerge in the local community because of the increased use of mobile phone for public services (e.g. solar kiosks that provide phone charging service); or to reach those who do not own mobile phones (such as community message broadcasters).

CONCLUSION

The ethical issues of software engineers may be more acute in some ways than for other types of engineers because of inherent differences between code and other engineering structures. Some of

Table 2. Examples of ethical issues from university experiences

Experience Contribution	Socially Relevant Computing	Innovation Lab
Avoid Harm	Can similar centers, but less affluent, utilize the educational tools? How dependent are the users on outside support for operating systems? Who is responsible for maintenance of software and devices?	Can non-literate mothers access application services? How a dependency on technology creates burden or isolate users where electricity is scarce? Would the application replace jobs in the community or isolate those who do not own a mobile phone?
Do Good	The stroke patient is more independent even for simple tasks like ordering a pizza. Involving the stroke patient and the children center in the innovation/implementation helped students to meet user needs.	Applications can minimize or eliminate expenses of transportation for community users. The use of open source software allows the solution to be adapted to different places and circumstances.

the peculiarities in the domain come from the development lifecycle and the drive to shorten development time. For example, web applications can be developed and deployed by one individual or a small group who can omit processes like software review. The lack of geographic constraints and the potential of reaching the entire world, when the software engineer involved might be unfamiliar with culture, users, laws, etc., present a special potential for both harm and good. This is not to say that software engineers should consider everything, but the range of ethical issues presents a challenge to the approach of accumulating resources that many ethicists highlighted, and proposed that the problem can be overcome by developing critical thinking skills as part of technical training courses (Herkert, 2002). The UNESCO report on Engineering Issues, Challenges and Opportunities for Development recognizes engineering studies as "a diverse, interdisciplinary arena of scholarly research and teaching built around a central question: What are the relationships among the technical and the non-technical dimensions of engineering practices, and how have these relationships evolved over time?" In addition to raising these questions, the report stressed the importance of involving researchers "as critical participants in the practices they study" that include engineering works but also "equity in engineering" and "engineering service to society" and concerned with the dynamics of gender, racial, ethnic, class, geopolitics, and so on (UNESCO, 2006).

The concepts of "socially relevant computing" and "technology for development" embed globally shared values expressed in United Nations declarations into engineering practice and bring closer ideas of how engineers can intervene to "change the world," which many 18–22 year olds aspire to. This is not to propose that the study of engineering becomes social or development studies, although the skill of the social scientist to go beneath the surface or the developmental worker to get close to the society's pressing needs, are both valuable. It is only to recognize that providing engineers with a broader education and critical minds is necessary for them to understand the societal value of what they do and the environmental and economic impacts of engineering designs and decisions, as well as contemporary ethical issues within and outside of the profession.

Although required ethics courses for software engineering students are still not the norm, ethics has begun to make its mark in curricula as evidenced by the many teaching and learning initiatives of individual educators and institutions who managed to create curriculum space for ethics education. Critical pedagogy, and other approaches like Survival Ethics, can be embedded into student outreach activities such as service learning or individual student projects. They are presented in this chapter as complementary to traditional (modules) and new teaching approaches (such as case studies, case studies combined with self-reflection) because of their potential to broaden as well as provide an applied component for teaching ethics. The practical emphasis in critical pedagogy can allow students to link specific design decisions and ethical positions, and can perhaps transform both student and teacher into persons more curious about their individual contribution to the public good. After all, they share with everyone else a basic human desire to survive and flourish.

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KEY TERMS AND DEFINITIONS

Computer and Information Ethics: This branch of applied ethics explores the social and ethical implications of Information and Com-

munication Technologies (ICT), including issues such as access, privacy, security.

Critical Pedagogy: This is an approach to education that is attributed to Paulo Freire. It addresses the issue of power in teaching and learning, and focuses on consciousness rising in the process of education.

Innovation Lab: This is defined by UNICEF as a physical space that allow for collaboration among private sector, academia and civil society. Related models include UN's Pulse Labs, Google Labs, and Enterprise Labs.

Rapid SMS: This is a free and open-source framework for building mobile applications with web-based dashboards that can be used for large-scale data collection, managing complex workflows, and automating data analysis.

Service Learning: This approach to teaching and learning involves students in activities that combine community service with academic experience, through a cycle of action and reflection to achieve the goals for the community and their personal development.

Software Engineering Ethics: This describes the set of ethical and professional responsibilities of software engineers in the design and development of software systems, drawn from computer science and engineering philosophy, principles, and practices.

Social Relevant Computing: This is an approach, developed by researchers at Universities of Buffalo and Rice in collaboration with Microsoft Research, for constructing Computer Science curriculum with focus on solving problems of personal or societal importance.

Technology for Development: Tech4Dev for short refers to the appropriate use of technology as part of the solution of a development problem in way acceptable to the stakeholders, socially, environmentally, economically, etc.

END NOTES

1 REFLECT Tools were originally developed for adult literacy and were widely used by development agencies worldwide. The method combines Freire's thematic approach with participatory tools linking learning to empowerment. It requires the involvement of learners in identifying learning (generative) themes where the traditional teacher role is replaced by a facilitator of learning who is trained on participatory tools. Learning groups generate their own learning materials by constructing maps, calendars, matrices, and diagrams or using drama, story-telling and songs to capture social, economic, cultural and political issues from their own environment. Find resources on REFLECT tools - retrieved from http://www.actionaid.org/main.aspx?PageID=128

2 Buckley M. et al. cited the 2005 figures published by the National Science Foundation which showed that the "U.S. graduated 54,588 bachelor degrees in Computer Science, but 86,031 in Psychology, 51,540 in Political Science,53,391 in English and Literature, 80,545 in Arts and Music, and 73,389 in Communications and Library Science." They also cited a New York Times article (2006) reporting that "more sports therapists graduated than engineers in the U.S." Interestingly, this state of affairs is not uniform worldwide. In Sudan for instance, computer science is a popular degree, evident by higher score requirements from applicants that social sciences degrees. This contrast, though worthy of speculation and analysis, is outside the scope of this chapter.

3 The authors describe that participating departments in the capstone course had their relevant learning outcome. For example, the Computer Science department the capstone course is about constructing a software engineering solution to a real-world problem

in a way that will give their freshmen, "a major exercise in computational modelling of structural risk assessment, and learning how to work with civil engineers" as well as with GIS experts and senior Computer Science students.

4 Work at the University of North Carolina is supported by the National Science Foundation (NSF) and is conducted as a summer research experience for undergraduates (especially women and minorities) to increase enrolment rates for doctoral degrees. Find information on the REU project from the NSF website at http://www.nsf.gov/awardsearch/showAward?AWD_ID=0851745&HistoricalAwards=false or from the University's website at https://reu.uncc.edu/research-projects. Howard University organised an NSF sponsored workshop on "Socially Relevant Computing" that was held in November 2010 in Accra Ghana and in August 2011 in Pretoria South Africa, which the chapter's author presented on her experiments with the concept in Sudan. UNISA's community engagement work, retrieved May 2014, from http://www.unisa.ac.za/Default.asp?Cmd=ViewContent&ContentID=96826

5 Innovation labs are becoming more popular in university settings. Harvard Innovation Lab is one of the early initiatives. In the UK, a number of universities established labs e.g. Bradford, Reading, Lancashire, Nottingham. Find information on the Institute of Enterprise and Innovation at Nottingham University (UK) at: http://www.nottingham.ac.uk/uniei/student-enterprise/enterprise-lab/index.aspx

6 This open source framework was a final year project at New York University and has since been developed and utilised by UNICEF innovation lab developers. Find about software on: http://www.rapidsms.org/ and about applications on http://unicefstories.org/

7 The evaluation of the innovation lab project is in the form of presentations and internal reports for the use of project stakeholders. Some information on the project are available on social media, see for example a post by Mr. Michael Bociurkiw (Head of Media & Communication Section – UNICEF Sudan CO) following the Final Event on 16th March at http://www.unicef.org/sudan/real-lives_7880.html and a post by the author on a follow-up project at http://unicefstories.org/2013/09/10/asthmasms-sudan-an-asthma-follow-up-system-using-rapidsms/).

8 This quote appeared in an article by Michael Buckley on the Microsoft External Research Newsletter downloadable from Sunny Buffalo website http://www.cse.buffalo.edu/~mikeb/SRC.pdf; and published on their website at http://research.microsoft.com/en-us/collaboration/focus/cs/src_solve-problems.aspx.

9 John Dewey, a North American philosopher, is another influential figure in progressive education. His book in 1933 entitled "How we think: a restatement of the relation of reflective thinking to the educative process" explores reflection as a central practice in critical thinking.

10 See (9) for source of quote of Sunny Buffalo student.

11 The Innovation Lab's ethical code was developed during the Team Preparation phase. It included four main obligations. The first towards the University campus rules of conduct and regulations on use of facilities; the second on the principles of innovation at UNICEF; and the third outlined the software engineer's code of ethics. The final part of the code laid out team members obligations towards each other, building on resources from Massachusetts Institute of Technology (MIT) at: http://web.mit.edu/2.009/www/codeOfEthics/codeOfEthics.html.

Chapter 17
Ethical Issues for User Involvement in Technological Research Projects:
Directives and Recommendations

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ABSTRACT

In recent years, it has become common for users to participate in the development of new technologies for health and quality of life. This development requires ethical issues to be taken into account. In this chapter, the researchers review the important recommendations and directives both worldwide and in European legislation in order to guide technological researchers. All research with human participants that poses any risk to them must be supervised by an external multidisciplinary entity. In addition, the participants must decide whether or not they want to participate, having been provided with all the information about the experiments and the risks of taking part. The privacy of the participants' personal data is another important issue.

INTRODUCTION

User involvement is an active process that involves users[1] or stakeholders[2] taking part in different phases of a project. Users should identify their preferences in order to develop new products that meet their needs with useful and easy-to-use-designs which will be successfully introduced into the market. The involvement of users and stakeholders in research projects requires the ethical and legal issues related to human participation in research to be taken into consideration to avoid bad practices. A number of cases can be found where research projects related to the patients' health have exceeded ethical boundaries and today we identify these as atrocities. Following these cases, some organizations regulated the human participation in research studies in order

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to ensure the physical and psychological safety of the participants over the research objectives and to ensure that their participation is voluntary, as it will be detailed further in this chapter.

This study focuses on the ethical implications related to the involvement of users in research studies to improve the design and development of new products, including technological devices for health and quality of life.

Some professions, such as journalism, psychology or medicine, adhere to a code of practice (European Parliament, 1993; Psychologist Official Colleges, 2010; Medical Colleges of Spain, 1999). These codes consist of criteria, rules and values that should be applied by the corresponding professionals. Codes of practice address ethical aspects and are increasingly common in new disciplines that involve working with human beings or require their participation. Moreover, in some professions the codes apply to difficult issues in professional life and sanctions are even included for non-compliant professionals. In the case of Spain, for example, some professions are regulated by law, such as the health-related professions (Spanish Government, 2003b) and the law (Ministry of Justice, 2001) where a reference to the code of practice can be found. However, in other cases, such as architecture and engineering, which have a corresponding law (Spanish Government, 1992), there is no reference to a code of practice, and in these professions involvement of human beings is also needed. The practitioners of these disciplines who conduct experiments with human participation must also take into account the applicable ethical issues and it is hard to find some guidelines for that. In some cases the ethical considerations can be subjective and dependent on other factors, such as culture, personal values and principles. With the aim of making an evaluation as objective as possible, there are some recommendations, rules and laws that every researcher conducting research with human participants should know. Different literature can be found on these ethical issues, which makes it difficult to analyze them, and some researchers in different disciplines do not know these ethical principles.

The National Society for Professional Engineering (NSPE) in the USA approved a Code of Ethics for Engineers (National Society of Professional Engineers, 2007), but, as Michelfelder and Jones (2011) explained, this and other similar codes for engineers do not talk "in terms of the safety, health, and welfare of the public".

Motivated by these problems, in this study we reviewed the existing and most important rules, recommendations and laws, focusing in particular on those in European legislation.

This work has been divided into five more sections:

1. **Bioethics Section:** Explaining the main principles concerning ethical issues related to the treatment of human subjects.
2. **Bioethics, Rules and Legislation:** Where the different rules concerning health-related technological research are discussed.
3. **Personal Data Protection:** Which is directly related to the above ethical issues, because the treatment of the personal data of the participants in the research must be appropriate.
4. **Conclusions and Recommendations**
5. **Future Research Directions**

BIOETHICS

The term "Bioethics" was first used in the 1970s (Potter, 1970). This word is composed of the two Greek words *bios* and *ethos*, which mean *life* and *science of customs* or *ethics* (Gracia, 2002). Bioethics examines the ethical issues related to life, such as medicine and biology in general, or the relationships between human beings and living things in general (Casado, 2008).

Bioethics can be divided into several disciplines, but in this case we will focus on Scientific Research Ethics. Its modern origin is the Nurem-

berg code of 1947 (U.S. Government, 1949) which will be analyzed later in this chapter.

In 1979, Beauchamp and Childress (2008) defined the four principles of bioethics that nowadays are well accepted and are applied in areas such as clinical bioethics. The principles are:

- **Deference to Autonomy:** This is the capacity of persons for deliberation and taking decisions that affect them. This principle indicates that all people have the right to be treated as autonomous beings. In the cases where the person has difficulty being autonomous (people with mental disability, severe cognitive problems, etc.) it must be justified why this principle could not be applied.
- **Non-Maleficence (*primum non nocere*):** This principle indicates that any harm must be prevented and no harm should intentionally be done to another individual. This applies to all areas of human life, not only to bioethics, and is punishable by law. This principle must be especially well interpreted in areas, such as medicine, where, in order to do good it is sometimes necessary to cause harm. Non-maleficence must be determined according to the principle of beneficence. The principle of non-maleficence first appears in the Belmont Report (The National Commission for the Protection of Humans Subjects of Biomedical and Behavioral Research, 1978), which will be analyzed later in this chapter.
- **Beneficence:** The definition of this principle is "doing good", or acting to benefit others. In the case of medicine there has been a paternalist tradition because, as the doctor is who knows the consequences, it is considered that he or she is the best person to decide. Sometimes the doctor and the patient may have different opinions about what is really good. Thus, the doctor's beneficence and the patient's autonomy are in tension.
- **Justice:** This principle is a mechanism to distribute resources impartially, trying to avoid inequality (ideological, social, cultural, economic, etc.). To cover this principle it is necessary to determine which equality or inequality is concerned.

These principles should not only be applied to research practices but also to the design of systems and new technologies.

- **Deference to Autonomy:** Not only should the researcher ensure that the participant is able to decide whether or not he or she wants to participate in the research, but the service or device being designed should also give the user the option of making decisions, rather than performing important actions automatically. This should be mainly controlled by the user.
- **Non-Maleficence:** Participants should not be subjected to any risk and if the risks cannot be avoided they must be minimized. The same premise should also be applied in the case of designing systems or services: the risks that can be minimized or avoided should be controlled with the aim of not harming the user.
- **Beneficence:** The participation of stakeholders in the research should in some way benefit either the participants or society in general, and the same applies to the service or device being developed.
- **Justice:** The treatment of all participating stakeholders should be equal and people should not be excluded because of their ideological, social or cultural situation. The design and development of new technologies should also ensure that different types of users will have the opportunity to use the final product; for example, special

access for people with disabilities may be required.

When these principles are in conflict with one another, it is not clear how to prioritize them. According to the work of Diego Gracia (1992), the principles can be divided into two levels:

1. The first level includes the "Non-maleficence" and "Justice" principles, which are considered as the "minimum ethics". This means that the principles included in this level are regulated by law, so there is an external obligation to comply with them.
2. The second level includes the "Autonomy" and "Beneficence" principles, considered as "maximum ethics" and related to personal values and what each person can ask of himself or herself, but cannot ask of others. The principles in this level are based on personal moral principles.

BIOETHICS: RULES AND LEGISLATION

As previously explained, bioethics is a subjective science, because it is sometimes governed by personal principles and values. This is the reason for defining four basic principles, trying to establish general rules that can be applied to anyone. Nonetheless, this is sometimes insufficient and therefore in recent years some rules have been written in relation to bioethics and to the human participation in research to ensure the safety of participants. In the following section we will analyze rules and laws related to research with human participants.

For international issues concerning bioethics, the *Universal Declaration of Human Rights* (United Nations, 1948) and the *Charter of Fundamental Rights* (European Union, 2000) should be considered as a starting point. The Universal Declaration applies to all citizens of United Nations member countries, and article 5 states: "No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment" (p. 2). The Charter of Fundamental Rights refers to all citizens of the European Union Member States and in its articles it defends "the right to life" (article 2, p. 9), "the right to liberty and security" (article 6, p. 10), and "the right to personal data protection" (article 8, p. 10), and states that "nobody should be subjected to torture or to inhuman or degrading treatment or punishment" (article 4, p. 9). Furthermore, article 13 defends the autonomy of the arts and sciences and states that academic freedom should be respected. From the perspective of this Charter, we will next refer to official documents that set out to regulate, from an ethical point of view, research and experiments with human beings.

In 1947 the *Code of Nuremberg* (U.S. Government, 1949) was written in response to the abuses by the Nazis in World War II and to the resultant trial in Nuremberg. In the beginning, this code had 10 guidelines which have been used for a long time. From this code, in 1964 the World Medical Association (WMA) wrote the *Declaration of Helsinki*, which has been revised several times, most recently in October 2013 (WMA, 2013). Despite the Declaration having no legal force, it is considered the most important document concerning ethics on research with human participants (WMA, 2009; Bošnjak, 2001; Tyebkhan, 2003). It currently has 37 paragraphs that have been completed during the years of revisions (i.e. 1975, 1982, 1989, 1996, 2000, 2002, 2004, 2008 and 2013). The Declaration of Helsinki makes the first mention of Ethics Committees as entities with the capacity for "consideration, comment, guidance and approval to a research" (article 23, p. 4), because, as the Declaration states, "in medical research involving human subjects, the well-being of the individual research subject must take precedence over all other interests" (article 8, p.2). Moreover, the mission of this document is to protect people who are unable to give their

consent to participate in any experiment, because they should only be included in the research if the research cannot be performed with other people. In cases where participants are unable to give their consent it must be given by a legal representative.

In 1978 in USA, a document similar to the Declaration of Helsinki was created titled the *Belmont Report* (The National Commission for the Protection of Humans Subjects of Biomedical and Behavioral Research, 1978). This report was created by the Department of Health, Education and Wellbeing of the USA after the infamous Tuskegee experiment. In the Tuskegee experiment, conducted over 40 years, the evolution of untreated syphilis was studied in black men by depriving them of any kind of treatment and lying to them about their participation in the study. In the USA, the Belmont Report is considered to be a document that summarizes the basic principles of research. In this report there is a special comment in relation to the need for informing the participants about the research and risks correctly and in an understandable way as well as in supporting the right of the participants to give or not give their consent freely.

The *Oviedo Convention* (Council of Europe, 1997) report, which was authored by the European Union in 1997, is also relevant. This report was signed by the 40 Member States and the USA, Canada, Japan, Australia and The Holy See. This is the first international tool that is legally binding for all the countries that signed it. The report protects the individual and his/her dignity in issues related to biology and medicine. This document, similarly to the Declaration of Helsinki, protects people who are unable to give their consent (article 6). Article 16 stipulates the requirements that any research with human participants needs to conform to. As with the Declaration of Helsinki, this report states that the projects must be supervised and approved by a multidisciplinary authority (in the Declaration of Helsinki this authority is called Ethics Committee). On the other hand, article 16 of the Oviedo Convention states that an experiment cannot be performed if the risks to the participants outweigh the possible benefits or if the participants do not give their written consent.

Due to advances in science and technology and the controversies that these advances have led to, in 2005 the United Nations (UN) issued its *Universal Declaration on Bioethics and Human Rights* (UNESCO, 2005). This Declaration includes the ethical basis defined in the Declaration of Helsinki, the Chapter of Fundamental Rights, the Universal Declaration on the Human Genome and Human Rights (UNESCO, 1997) and the International Declaration on Human Genetic Data (UNESCO, 2003). The Universal Declaration on Bioethics and Human Rights takes into account the fact that scientific and technological advances have helped to extend human life expectancy and improve the quality of life. At the same time, the UN was conscious of the ethical decisions related to medicine having implications for human beings. For all those reasons, ethical issues should be considered during scientific and technological developments. Therefore, bioethics should play an important part in the decisions taken in future projects. The main objective of this Declaration is to define the universal principles based on common ethical values to guide the development of scientific and technological advances, because ethical issues should be part of these developments. Through this Declaration it is intended that all people should enjoy the same ethical rules in relation to medicine and life sciences. According to this declaration "direct and indirect benefits to patients, research participants and other affected individuals should be maximized and any possible harm to such individuals should be minimized" (article 4, p. 7) and "any medical intervention is only to be carried out with the prior, free and informed consent of the person concerned" (p. 7), who will receive all the information in a comprehensive way (article 6). As in the previously mentioned documents, this declaration also discusses people who are unable to give their consent, stating that they should only

participate in the experiments if their participation is necessary and it can be demonstrated that without their participation the expected results cannot be obtained. It also states that if they do not want to participate this must be taken into account (article 7). This is the first document related to bioethics where a reference to the privacy of the data collected during the research can be found (article 9). The Universal Declaration on Bioethics also mentions the ethical committees, who according to this declaration should evaluate any type of ethical, legal, scientific or social conflict that could appear in research projects. They should also advise on ethical problems and should evaluate the scientific and technological progress.

The projects of The Seventh Framework Programme (FP7) are a reference for Publicly Financed European Projects. This program is a European Union (EU) strategy to avoid social exclusion, focusing on the ethical issues (McLean, 2011). Conscious of the ethical implications in Assistive Technologies (AT), the EU published ethical recommendations for the researches working on projects funded by the FP7 (Pauwels, 2007). This guide can be used in any research project with human participation and therefore any ethical considerations should be included. The guide provides a definition of the most relevant ethical issues, the way the committee of this program is formed and the ethical issues that need to be taken into account in the evaluation of projects. As in the previously mentioned documents, this guide mentions the need to obtain an informed consent from the participants, stating that this consent should be voluntarily and freely signed; it should include all the information related to the experiment as well as the risks and benefits; and all this information should be provided in a language that is comprehensible to the participants. Moreover, the Commission discusses the privacy and confidentiality of the data collected during the research and in this case the guide is based on the European Directive 95/46/CE (European Parliament, 1995), which will be explained later in this chapter.

The EU also funds some projects – in The Sixth Framework Programme (FP6) (European Commission, 2013a), FP7 (European Commission, 2013b), Competitiveness and Innovation Framework Programme (CIP) (European Commission, 2013c) and Ambient Assisted Living Joint Programme (AAL) (Ambient Assisted Living, 2012) – which focus on ethical, social, legal and human rights implications of Information and Communications Technology (ICT) for the elderly (Cavallaro, Morin, Garzo, Remazeilles, Rentería, & Gaminde, 2012). These projects include ETHICBOTS (Science and Society, 2008), SENIOR (Senior project, 2008), ETICA (Plone Foundation, 2013), and Value Ageing (Marie Curie Industry–Academia Partnerships and Pathways (IAPP), 2013), which investigate the ethical issues related to the development of new technologies for the daily use of different populations from the point of view of multidisciplinary teams and focusing on projects in different technological areas and involving different stakeholders.

The analyzed Declarations state that every country has the right to generate its own laws for complying with them. In most of the European countries we can find several different laws and recommendations. In this chapter we analyze the laws from Spain, which are similar to the ones in other countries.

In Spain the *General Health Law* (Spanish Government, 1986) focuses on the organization of and the services provided by state health centers. Article 10 discusses the rights of any person involved in health services. That article explains that every person has the right to the confidentiality of their data; to be informed, in a comprehensible way and using formats that are appropriate and accessible to people with disabilities about any teaching or research procedure to be applied to him/her (Spanish Government, 2011); and to the freedom to decide whether he or she wants to participate in that procedure. Furthermore, in

cases where his/her health is at risk the patient must give specific consent. Article 106 of this law stipulates that any researcher in this field should contribute to improving the health of the population, which is closely related to the beneficence principle of bioethics.

There is also the *Law on Patient Autonomy* (Spanish Government, 2002b). The main aim of this law is to regulate the rights and obligations of the patients, users and professionals with respect to the autonomy of patients and their information and to clinical documentation. This law, as does the General Health Law, specifies that the patient must be correctly informed about any intervention that he or she will undergo, using the appropriate language. It also stresses that any intervention requires the patient's informed consent, which can be obtained either verbally or in writing. It is mandatory to get written informed consent in the following cases: surgery, invasive diagnostic and therapeutic procedures and any procedure that involves risks. In the case of patients with disabilities, they must take part in the decision-making process and they must receive the support necessary to make their decision (Spanish Government, 2011). Finally, this law references the confidentiality of patients' medical data, stating that any information collected and related to patients' health should be treated as stipulated in the *Organic Law on the Protection of Personal Data* (Spanish Government, 1999). This Organic Law will be explained later in this chapter.

The *Law on Biomedical Research* (Spanish Government, 2007), similar to the previously mentioned laws, states that the participant should be correctly informed (article 15) and that he or she must give his/her specific consent to participate in any procedure (article 13). Moreover, in the general principles of the law it is stipulated that any research must not involve undue risks for the participant compared to the benefits (article 14). As this law states: "biomedical and health sciences research is an important tool to improve the quality and expectancy of life" (p. 28826). To advance in this field it is increasingly common that human research involves invasive procedures. This creates significant ethical and legal uncertainty, which must be regulated. The main aim of this law is to ensure respect for and the protection of participants' fundamental rights. This law states that the Ethics Research Committees are mandated to ensure that the methodological, ethical and legal aspects of research with human participants are appropriate.

Apart from the legislation mentioned in this paper, the recommendations of the Human–Computer Interaction Association (the acronym in Spanish is AIPO, which is formed by the Spanish words Asociación de Interacción Persona Ordenador) had been considered. This covers research with human participants for developing new technologies, especially the participation of end users in usability testing. AIPO is a professional association that is open to any professional interested in Human–Computer Interaction, mainly in Latin America. The objectives of this Association are to promote and spread research into Human–Computer Interaction, and to provide a link between the researchers and the professionals working in this field. This Association has written an ethical code (Concejero, 2006) for usability testing performed with end users. The code includes recommendations for researchers working in the field of Human–Computer Interaction. These recommendations are based on the ethical codes for psychological research and consultancy (British Psychological Society, 2013; American Psychological Association, 2013). Some of these recommendations state that the participants should be referred to as "participants" or "users", and never as "subjects". The recommendations also state that all the participants must be treated in the same way, independently of their race, ethnicity and social status. They also state that the risks must be minimized, that all data collected must be anonymized and that the consent of the participants is necessary for the collection of these data. The participants must decide whether they

want to participate and in order to decide they must be properly informed; and if they decide to participate they must be able to leave the study whenever they wish. This document also states that sometimes not all the necessary information can be provided to the participant, because the results could be changed depending on the information they have. In these cases, when the research has finished the participant must receive all the information about it and he or she must be informed about why he or she did not receive all the information from the beginning.

PERSONAL DATA PROTECTION

As mentioned earlier, the recommendations and laws involve the right to privacy and dignity, because this is a fundamental right. To enforce this right, there are several European Parliament directives and recommendations on data protection. These recommendations need to be applied for participants in research related to health and quality of life, because this type of information is considered to be sensitive data.

In this section, the recommendations issued by the European Union and the countries laws will be reviewed.

Directive 95/46/CE of the European Parliament and of the Council (European Parliament, 1995) on the protection of individuals with regard to the processing of personal data and the free movement of such data is the reference text for countries in the European Union. It creates a regulatory framework for the protection of research participants and their personal data in the European Union. This Directive limits the collection and use of the personal data and suggests the creation of a national agency in each of the countries of the European Union. It states that personal data should be "collected for specified, explicit and legitimate purposes" (article 6, p. 12) and can only be collected if the person gives his/her consent, except in certain cases; such as part of a contract, any juridical obligation, to protect the life of that person, a public interest, or in the interests of the person affected. This Directive also creates different categories according to the type of personal data, considering some of them to be especially private, such as data concerning ethnic or racial origin, political, religious or philosophical beliefs, trade union membership, and sexual and health-related information. Furthermore, it states that the interested person shall have the right to know about these data and to change, remove or block them. Moreover, he or she shall have the right to object to the treatment of the data and to be informed if they will be made available to others. This European Directive suggests a national authority to control this treatment which should know about the personal data that will be collected.

Two years after the Directive on Personal Data Protection was published, and driven by increases in the use of medical data and the sensitivity of such data, the Committee of Ministers of the Council of Europe issued some recommendations concerning the treatment of medical data (Committee of Ministers of the Council of Europe, 1997). This recommendation applies to the automated collection and treatment of any medical data, except in cases where the National law provides other rules. According to these recommendations medical data shall be obtained from the data subject and the subject individual must be informed about the file that contains the data, why the data is being collected, the persons or entities that will access the data and why they will access the data, the possibility of withdrawing his/her consent, the data of the person responsible for the file and how to proceed if he or she wants to access or modify the data. In this case it is also stipulated that comprehensive information should be provided to the person affected, and that when this person is unable to give his/her consent the person legally responsible for giving the consent should be properly informed. Moreover, in these recommendations it is stated that "medical data must not be stored longer than is necessary" (article

10, p. 25) for the purpose for which they were collected and processed. With regard to the health data collected for a scientific research project, the European Parliament is clear and says that if possible the data must be anonymous.

According to the European Directive, each country should administrate those recommendations and could create laws for that. In this case, we analyzed Spanish legislation to see if it is true that those recommendations have been taken into account and if they defined anything else related to personal data protection and privacy.

In this analysis we found that article 18 of the Spanish Constitution (Congress of Deputies, 1978) states that the privacy, honor and dignity of people living in Spain must be protected, and that the laws necessary for this should be enacted. The Personal Data Protection Organic Law (LOPD, which is its acronym based on Spanish words "Ley Orgánica de Protección de Datos", meaning "Personal Data Protection Organic Law") (Spanish Government, 1999), published in 1999, adapted Directive 95/46/CE of the European Parliament and of the Council to the Spanish laws. The LOPD, according to the European Directive, states that the person from whom the data will be collected must be properly informed and that the data should only be used for the purpose for which they were collected. Moreover, the affected person shall have the right to correct, amend or delete the data whenever he or she wants to. This law also states that when the data are not needed for the purpose for which they were collected, or when the affected person requests it, these data should be deleted, except if they are needed because of civil liability. In this last case, the data will be blocked[3] for about 4 or 5 years. The LOPD also states that the consent of the affected person is needed for the disclosure of data to others. In cases where the affected person is unable to give his/her consent (because he or she is under 14 years of age or because he or she is legally disabled for other reasons) his/her legal representative will be the person responsible for giving the consent. There are two different types of consent: tacit[4] and explicit.[5] This law, according to the European Directive, protects the data related to ideology, religion, beliefs, trade union membership, racial or ethnic origin, and health and sex life, and with this aim it states that for the collection of these data the consent of the interested person must be explicit and written. The LOPD also states that the person responsible for the files should "ensure the security of personal data and avoid its alteration, loss, unauthorized process or unauthorized access" (p. 43090) and "maintain professional secrecy about the personal data for which he or she is responsible" (p. 43090).

Files containing personal data must be registered with the Spanish Agency for Data Protection (the acronym is AGPD which is formed from the Spanish words Agencia Española de Protección de Datos), which is responsible for ensuring compliance with the Personal Data Protection Law and the Royal Decree (Ministry of Justice, 2007) containing the Regulations concerning the Personal Data Protection Law. This Royal Decree describes the way in which personal data should be treated. Personal data is divided into three different levels:

- **Basic Level:** The security measures at this level must be applied to all files containing personal data.
- **Medium Level:** Information on administrative or criminal violations, taxes, financial services, work accidents and professional diseases, information that provides a definition of the characteristics or personality of individuals and used to evaluate certain aspects of personality or behavior. Basic and medium level security measures are applied to these data.
- **High Level:** Basic and medium level security measures should be applied to the data at this level, as well as the special security measures for this level. Data relating to ideology, union membership, religion, creed, ethnicity, health or sexual life, data

obtained without the consent of the affected person, and data concerning acts of violence against women and police records will be included in this level.

The AGPD issued guidelines (Agencia Española de Protección de Datos, 2008) explaining the classification of personal data and the different levels of protection that are applicable in each case to ensure compliance with the Personal Data Protection Law and the Regulation linked to this law. Other countries, also, such as European Union member states, Island, Liechtenstein, Norway, Switzerland, Argentina, Guernsey, Man Island, USA (the states adhered to *safe harbor* principles) and Canada have the same level of personal data protection.

In Spain, further legislation related to the LOPD law can also be found related to the electronic format of personal data or to telecommunications:

- Law 34/2002 (Spanish Government, 2002a) on personal data stored on computer servers.
- Law 32/2003 (Spanish Government, 2003a) on data managed by the telecommunication companies.
- Royal Decree 424/2005 (Ministry of Industry, Tourism and Trade, 2005) on the conditions for the provision of electronic communications services, universal service and consumer protection.

CONCLUSIONS

There are various directives and laws related to ethical issues concerning research with human participants, and all of them agree on the following:

- Any participation in any research project must be voluntary and the participants must be informed that they can decide whether or not they want to participate, and that they can leave the experiment at any time without giving any explanation.
- Moreover, the participants shall receive any necessary information about the experiments, the benefits and inconveniences, in a comprehensible language, to make a decision on their participation.
- When participants decide to take part in the research project they must give their consent, preferably in writing.
- People who are unable to give their consent should only participate when there is no research alternative of comparable effectiveness with research participants able to give their consent. In this case his/her legal representative must give the consent.
- All the collected data will be treated with confidentiality and privacy, and the participant will be informed of this.
- Any research conducted with human participants must be supervised by a competent and multidisciplinary entity which shall evaluate the relevant ethical issues. According to Spanish law this entity should be an ethics committee.

We can conclude that all the personal data collected during research should be private and confidential and preferably anonymous. The interested person should be correctly informed of the data being collected and should give his/her consent. Moreover, the interested person should be able to request the data to be blocked, deleted, amended or updated whenever he or she wants. If it is necessary to give the data to another company the interested person should be informed and he or she should give his/her consent. The data should only be used for the purpose for which they were collected. Both the European Directives and laws demand certain security measures according to the type of data, which will be more restrictive in the case of health data, inter alia. In Spain, for

example, all the data collected should be registered with the AGPD.

RECOMMENDATIONS

According to the conclusions of the analyzed legislation and recommendations, we defined some guidelines for researchers to take into account before doing any experimentation with humans.

First the information to the user is important, so this process must include (Marijuan & Ruiz, 2009):

- Enough information about the procedure, objectives, risks and benefits.
- Any additional information that the participant asks will be provided, and the participant could ask for this information at any moment.
- The information will be provided in an understandable language, and the researcher should check that is well understood by him/her. Try to avoid technical language.
- At the end, the participant must freely decide if he or she is interested in participate or not. Anyway, if he or she decides to participate and during the experimentation change his/her mind, he or she will have the opportunity of leaving the experimentation.

Information consent is a process to inform the participant. Every explanation to the participant should be given talking, but in some cases the acceptance of this consent should be written (according to the personal data protection directives, for example, if the collected data are especially sensible). Because of all of this, we propose to prepare a document to be given to the participant, and which will be explained to him/her before starting the experimentation. This document should include at least the following sections (Simón & Concheiro, 1993; Basque Government, 2011; University of Colorado Boulder, 2013):

- Project name
- Name of the responsible researcher of the project
- Short summary of the project
- Information regarding the experimentation including:
  - Description
  - Objectives
  - Methodology
  - Duration
  - Information that will be collected
  - Benefits
  - Discomforts, risks or possible adverse events
- Personal data treatment (according to the legislation)
- Some clarifications such as:
  - The participation is voluntary.
  - The participant can leave the experimentation whenever he or she wants.
  - He or she can ask as much information he or she wants at any moment.
  - Researchers must maintain confidentiality.
  - If the experimentation will be supervised by any Ethical Committee this information must be included.
- Research team contact data

If the document has to be signed by the participant, because a spoken consent is not enough, the document should include some legal sentences such as "I (name) understood the information and give my consent freely. I understood that my participation is voluntary. I let the researchers collecting my personal data to be treated according to the legislation".

In the case of people that cannot give their consent because they are less than 14 or they have cognitive impairments, the legal representative should give the consent. For that, this represen-

tative must certify as such and should be also informed about the experimentation procedure. Moreover, if the participant decides not to participate his/her opinion must be taken into account.

According to the recommendations the experiments with new technologies[6] that have some risks to the participants should be supervised by an external Ethical Committee. In these cases, each Ethical Committee has different requirements or templates to be filled. But after analyzing some of them we saw that the kind of information asked by the committees is very similar. This information can be summarized like this (Basque Government, 2011; University of Colorado Boulder, 2013):

- Informed consent document and process.
- Title of experimentation.
- Information about the person responsible for the experimentation and the researchers that will work on it.
- Objectives.
- State of the art about similar experimentations or related to the study.
- Similar previous studies.
- Design of the study including the methodology that will be applied.
- Participants: number, characteristics, inclusion and exclusion criteria.
- Recruitment process.
- Compensation to the participants.
- Personal data process and resources to ensure privacy.
- Risk analysis including the mechanisms to minimize them.
- Benefits.
- Compensation in case of damages.
- Costs for the participants.
- Technical specifications of the devices that will be used.
- Post information to the participants.

Also, we recommend researchers to fill a document with all this information because it will help them analyze the risks of the experiments to decide whether the supervision of the Ethical Committees is necessary, and also to design a good experiment because this information can be used as a guideline during the information consent process and experimentation.

FUTURE RESEARCH DIRECTIONS

In this chapter different recommendations and legislation on research with human participants have been reviewed. When we consider research with human participants it is clear that we must also include the privacy of the data collected, so the legislation related to personal data is important in this field. In this research we studied the international legislation and focused on European and Spanish recommendations, but similar legislation can be found in other countries in Europe and worldwide.

In recent years, the involvement of users in the development of Technological Centers for improving the design or adapting the usage, usefulness or accessibility of the devices is very common. However, researchers typically lose sight of the ethics in favor of the technological advances. Because of this, the information collected in this work is very important for all researchers who perform research with human participants, because this type of research is well regulated in most of the European countries and USA that conduct this research.

Research made around health care should be taken into account, not only the research made with drugs, but also research in medical devices or technological devices for improving the quality of life. This type of research is considered quite sensitive and the data used and collected during the research should be stored with special care.

The data collected during any research must be treated with confidentiality and privacy. Depending on the type of the personal data collected, the researchers must guarantee different levels of

privacy and security, according to the laws of the country where the personal data are being stored.

After reviewing different legislation of different countries we can say that countries in the European Union have similar legislation. As previously mentioned this study focuses on Europe, but future studies could be performed for other countries or compare the legislation of different countries. It would be very interesting to study the legislation from countries outside the European Union or the United Nations, such as Asian or African countries, because, as Reisch (2011) said in his research, different lands have different ethical considerations and ethical issues such as privacy or informed consent must be adapted to the place where the research will take place.

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KEY TERMS AND DEFINITIONS

Autonomy: Power to take decisions for its own on certain issues.

Confidentiality: Duty of not revealing information to others.

Ethical Committee: The organization or entity that is responsible to examine human actions and judges human actions in accordance with ethical rules.

Ethics: Moral rules to judge human actions.

Informed Consent: A document that informs individual(s) about a procedure or a task where individual(s) may give their consent.

Personal data: Any kind of data related to an individual or that could be identified with a person.

Privacy: Right of a person of not being public.

User: The person that uses the application, device or service.

END NOTES

[1] User: every individual who interacts with the system (International Organization for Standarization, 1999).

[2] Stakeholder: individual or organization having a right, share, claim or interest in a system or in its possession of characteristics that meet their needs and expectations (International Organization for Standarization, 2010). In the case of this study we will use *user* and *stakeholder* with the meaning of user, relatives, caregivers, health professionals or devices prescriber, equally, because we understand that any of them could interact with the new technologies for the health and quality of life.

[3] Blocked: the data cannot be used, but will be stored until the end of the civil liability that is applied to them (Spanish Government 1999).

[4] Tacit consent: it is considered that the person gives his/her consent if he or she does not say the opposite. He or she has 30 days to refuse to give consent and if he or she does not say anything it is considered that he or she cannot refuse consent after this period.

[5] Explicit consent: in this case the affected person must express his/her consent. Normally he or she should do it in writing.

[6] We are not talking about experiments with drugs or health products.

Conclusion

ENGINEERING ETHICS IN THE INTERNATIONAL ARENA

Engineering ethics is coming of age. This claim is true in at least two respects. First, engineering ethics has undergone an internal evolution in the direction of increasing depth and breadth in its treatment of the issues appropriate to the discipline. In the early years, three or four decades ago, engineering ethics was dominated by discussions of relatively few cases, usually involving engineers blowing the whistle in an attempt to prevent threats to public health and safety. Now it includes topics such as risk, the environment, the relationship of engineers to managers, the relationship of technology to the larger society and to value issues, individual and group responsibility for technology, the proper place of professional codes and professional societies—and the list is growing!

The second way in which engineering ethics is coming of age is that it is becoming a truly international discipline, following a trend in the engineering profession itself. One manifestation of the trend toward globalization is the emergence of worldwide standards for the technical education of engineers, as represented by the Washington Accord (1989). The signatories to the Accord agree to "substantial equivalence" in the standards for undergraduate education. Similar agreements have been signed regarding engineering technology (Sydney Accord 2001) and engineering technicians (Dublin Accord 2002). As of now, roughly a dozen countries have signed the agreements, but the list of signatories is bound to grow.

The licensing of engineers has also taken on an international dimension, with the establishment of the Eur Ing title by the Federation Europeenne d'Associations Nationales d'Ingenieurs (FEANI) or the European Federation of National Engineering Associations, which celebrated its sixtieth anniversary in 2012. The Eur Ing, which is much like the P.E. license in the U.S., is accepted in more than 30 countries. Whether the trend toward licensure follows the Eur Ing transnational model or the P.E. national model, emphasis on licensing and registering engineers is almost certain to grow throughout the world.

The movement toward the globalization of engineering raises new issues for teaching and research in engineering ethics that have not heretofore been addressed. Many of these issues have been addressed in this volume. I mention four such issues that seem to me to have particular urgency. First, engineers around the world must come to understand themselves as professionals. Some scholars are convinced that the notions of "professional" and "professionalism," being Western in origin, cannot be exported to the global scene, at least with respect to engineers. Japanese scholar Tetsuji Iseda (2008) is one who believes this. Iseda has argued that intrinsic to the Western concept of professionalism is an implicit social contract, according to which professionals (in this case, engineers) agree to self-regulation and high standards of competence, in exchange for high socioeconomic status. In Japan, however, engineers earn less than social scientists and have comparatively low social status. As a result, Iseda believes, engineers

in Japan do not think of themselves as "professionals" in the Western sense and cannot be motivated to ethical conduct by thinking of themselves as professionals. Other scholars have made similar arguments to me, often maintaining that the notion of professionalism is too individualistic to be appropriate for the more group-oriented Asian cultures.

Despite these claims, engineering organizations in Asia continue to promote the concept of professionalism as applicable to engineers in their part of the world. The Federation of Engineering Institutions of Asia and the Pacific (FEIAP, n.d.) has as its goal the encouragement of social and economic progress through the application of technology and the advancement of "engineering as a profession in the interest of all people . . . ." The Commonwealth Engineers Council (CEC, n.d.), with members in 44 countries, was established to "advance the science, art and practice of engineering for the benefit of mankind." Its website continues: "As engineers we recognize our responsibility of working closely with other professions and with the engineering community at large." Whatever the outcome of this debate, engineering ethicists have the opportunity to contribute to the discussion of the meaning and relevance of professionalism, admittedly a Western concept, in the international arena.

In this writer's opinion, engineers should be encouraged to think about professionalism in universal or global terms. One way this might be done is to point out that a profession is a social role, and all, or virtually all, cultures recognize the existence of social roles, each role carrying its own set of obligations and prerogatives. One thinks of the role of child, parent, government minister, religious leader, etc. (Harris, Pritchard, Rabins, James, & Englehardt, 2012). In more group-oriented cultures, it may be more appropriate to think of professional obligations as obligations of a professional group to the larger society, rather than as individual obligations.

A second issue is the increasing necessity for engineers to appreciate the interaction between technology and culture. As scholars in Science and Technology Studies (STS) have shown, social values often influence the direction of technological development. It is not enough to say that technology has its own internal logic, such that one step in technological progress builds on another, as the steamboat might be said to follow the sailboat. Social concerns often determine the direction in which technology moves. To cite one of the standard examples, Pinch and Bijker (1987) have shown that the early evolution of the bicycle was influenced by social considerations: the more utilitarian version came to be more widely acceptable than the bicycle with the large front wheel, which finally disappeared. Even more difficult for engineers to appreciate, in my opinion, is how technology can modify our values. The ability to see the human form of a developing fetus by various types of imaging has probably affected conceptions of the moral status of the fetus. Cell phones and social networking platforms may well be changing our views about privacy. Although these examples originated in Western societies, similar causal interactions between technologies and norms and social practices probably exist in most societies.

Engineers and engineering students tend to resist the view that there is a causal interrelationship between technology on the one hand and values and social practices on the other, preferring to see technology as value neutral, thereby shifting the responsibility for ethical deliberation on how these technologies are used to those outside the engineering profession, such as political and religious leaders. This tendency may even be stronger with engineers in non-Western societies, where technology is sometimes held in suspicion precisely because it is seen as a vehicle for importing values seen as subverting traditional cultural and religious norms. Classroom discussions by engineering students of such issues as they relate in their own culture can assist in the transition from the view of technology as value neutral to a more adequate understanding of the complex and subtle ways in which technology can to some extent be malleable to different value orientations, but at the same time can influence those same values.

A third way in which the internationalization of engineering makes new demands on the discipline of engineering ethics and engineering ethics pedagogy is the necessity of making decisions produced by conflicts of values and practices among societies. We can call these "boundary-crossing issues." A major challenge here is to know when to follow the values and practices of another culture—"When in Rome, do as the Romans do"—and when to refuse to comply, because compliance would result in serious compromise of one's own moral values. Can one accept a degree of nepotism when it is practiced and perhaps even morally obligatory in a society in which one is doing business? What about paying extortion to a customs agent in order to be able to import goods that are perfectly legal? Is it morally permissible to paternalistically force workers to wear safety helmets or to live in more sanitary conditions for their own well-being, even when such practices seem to violate their own norms? When and to what extent is it legitimate for an engineer to acquiesce to norms involving the treatment of women in cultures whose values are different from one's own?

A fourth requirement of engineers in a globalized environment is that they be able to communicate across language and cultural differences. It is not easy to accord moral respect to those whose values in some areas are profoundly different from one's own, and yet a certain degree of mutual respect seems essential to effective communication. It is useful, however, to appreciate that value different from one's own can be sincerely held, and that others may be willing to accept a considerable degree of personal sacrifice in order to hold to those values.

Exploring the challenges of communicating across cultural divides can be aided by the use of cases. Most of the early cases in engineering ethics, such as the Challenger, were based on incidents in the United States, and these can be useful to non-U.S. engineers in understanding conditions in the U.S.; they may not be as useful in helping U.S. engineers understand cultural and value differences abroad. Thus, cases appropriate to Latin America, China, India, and other cultures are needed. These cases must highlight problems and issues that are important to engineers in various situations. In many countries, for example, most large projects are financed by governments, and these governments are often non-democratic. Engineers who protest unethical practices may face not only dismissal, but also jail sentences or worse. Corruption also appears to be a more severe problem in some countries than in the United States.

The essays in this volume should contribute to the discussion of ethical and professional issues in engineering, as they increasingly assume an international character. The engineering profession, given its power and influence in the contemporary world, deserves this attention.

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Afterword

ETHICS, ENGINEERING, AND PUBLIC IMAGINATION

While many people start realizing how much technology impacts their lives, few think of technology, infrastructure, and engineering as having anything to do with ethics. Let alone that, members of the general public are aware of the existence of the academic areas so familiar to the author of this book—engineering ethics, ethics of technology, science and technology studies. It is easy to forget this, especially because scholarship in these areas has been growing and flourishing during the past decades. But if we want to improve the situation, it is important to reflect on why this gap persists.

While thinking of ethics most people assume a distinction between "human" areas and "things" areas ("non-human"). Technology and engineering are seen as belonging to the "things" part, whereas ethics is perceived as having to do with humans and their actions. In spite of all the hard work done by philosophers of technology and other thinkers about technology, this is still the picture assumed by most people, and it is difficult to change that. The result is that it is relatively easy to convince people that ethical evaluation is necessary in areas such as medicine and health care or even business, which are perceived as "human," but that it is really hard to have people fully realize that technology, infrastructure, and engineering are suffused with specific and difficult ethical questions and that ethical evaluation and studies in these areas is as much needed as in others.

Indeed, it is astonishing how accepted for instance medical ethics is as compared to ethics of technology. It is not only much more developed as an academic discipline, ethical evaluation in this field is by now also well established. It is also integrated in medical practices. There are ethical committees that review research proposals and oversee medical decisions. Students in medicine, nursing, and so on are educated in ethics. There is a relatively large number of academics who make their living with this kind of ethics.

Ethics of technology, by contrast, is still a rare bird, especially when not immediately relevant to medicine or anything "bio." Of course, there is an increasing number of scholars, journals, organizations, conferences, and other academic activities now, there are some graduate programs in the area, and there are some exceptions where ethical evaluation is applied before the technology is developed. Consider for instance the new research funding scheme of the European Commission and (other) national programs of "responsible research and innovation" in Europe. But the numbers and the extent to which technological practices are actually influenced by, say, an ethical committee or by ethical reviewers who look specifically at the ethics of technology and engineering are somewhat disappointing. Despite applaudable, significant, and continuing efforts by many people in the field to increase and deepen scholarship, education, and practice in this area, there is still a long way to go.

Can we speed up this positive and encouraging, but all too slow development? Sadly, the one thing that is rather successful in increasing more general awareness about ethics of technology and related issues is often a disaster, a case where things have gone terribly wrong, or, in the best case, a story about a disaster or a worst-case scenario. We often only realize how dependent we are on technology and on those who design and maintain it once things go awfully wrong. This is also the case in the (related) area of environmental ethics: catastrophes and doom scenarios are often wake up calls. Should we wait for the next technological disaster to happen before technology is seen as an ethical matter that needs far more resources than it gets now? I hope not, of course, but I am afraid this is the situation we are in now with regard to ethical questions raised by new and emerging technologies, and we better at least try to imagine what could go wrong if current technological developments continue in the direction they are going now (or can be foreseen to go).

Consider our dependence on Information and Communication Technology (ICT). Luckily, we have not (yet?) experienced the equivalent of a nuclear disaster. Cases where things went wrong are limited. But, this also means that there is generally a lack of sufficient public debate about the ethics of technology and engineering. We live like people who live in a vulnerable area but think they do not need protection against floods. In the area of ICT we might well need the equivalent of the Dutch storm surge barriers to prevent worst to happen. If we want to deal with the current and future technological vulnerabilities, we need ethical-technological "flood control." We need to re-direct the design and use of technology in ways that mitigate ethical risks and contribute to our vision of a better world. Of course, it is difficult to foresee all possible consequences of a technology, and we can never fully "design" the technological future, if we should even attempt to do so at all. But unless ethical reflection and evaluation are more integrated in technological design, use, and policy, society will keep a dangerous blind spot.

It seems that academic efforts to make this happen in practice, for example in the form of "technology assessment" and "research and responsible innovation," are insufficient. Maybe this is partly so because academics are given, and assume, the role of scientific "experts" who have to produce thoughtful articles, balanced reports, careful evaluations, and reasonable advice. And of course all of this is necessary. But what is missing in most of these articles, reports, evaluations, and advices is sufficient engagement with, and stimulation of, the public imagination. There is too little interaction between key academics in the field and those in the media, in politics, in business, and elsewhere who are (far more) successful in shaping the public imagination concerning technology and who play a role in public discussions about technology, but usually lack a deeper understanding of the ethical issues raised by it.

If we want more rapid change when it comes to ethics of technology, therefore, we need not only the reflection and the understanding, but also the imagination, the emotions, the pictures. We need the doom scenarios, perhaps, especially in order to increase awareness. Yet what we need most is a positive, common vision of where we want to go. Unless we are able to collaboratively and collectively imagine a better society and better technologies, we risk to sleepwalk into a future no one wants. We will keep fine-tuning things that are about to disappear. And most of us will be in the hands of those who design our future without asking us where we want to go. Both directions are possible. They are possible because, after all, technology has much, if not everything to do with humans and human values. Ethics of technology and engineering ethics are, in the end and in a deeper sense, a kind of bioethics: they have to do with life, with human lives and other lives, especially with how we live our lives and what this means for other lives. Since ancient times this is what ethics is all about.

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